THE IMPORTANCE OF PLANT DISEASE MANAGEMENT IN U.S. PRODUCTION OF LEAFY GREEN VEGETABLES

Prepared by

**The National Agricultural Pesticide Impact
Assessment Program (NAPIAP)**

United States Department of Agriculture

JUNE 1994

**NAPIAP Report
Number 1-CA-94**

This document is dedicated to
Dr. John "Jack" K. Springer, team leader and author of the biological chapters. Dr. Springer died suddenly on February 5, 1994. NAPIAP has benefited greatly from his expertise and we gratefully acknowledge his work and cooperation.

PREFACE

This report was a joint project of the United States Department of Agriculture (USDA) and the State Land-Grant Universities and was supported via a grant (No. 92-EPIX-1-0097) from the USDA National Agricultural Pesticide Impact Assessment Program (NAPIAP). It was prepared by a team of State Cooperative Extension Service and Experiment Station scientists who provided sound, current scientific information on pest management practices on collards, kale, mustard greens, turnip greens, lettuce and spinach. The chairpersons, Drs. John K. Springer and George C. Hamilton, were instrumental in planning, coordinating and implementing this study in cooperation with USDA agencies (Agricultural Research Service, Extension Service, Economic Research Service).

The intent of the assessment was to determine the effect on leafy green vegetable production of the withdrawal of individual and groups of fungicides. For purposes of analysis and explanation, data were collected on the economically important diseases, pesticide usage, and nonpesticide pest management practices.

Special appreciation is expressed to Mrs. Laye Nagahiro and Mrs. Irene Kaneshiki for their assistance in preparation of this manuscript.

ACKNOWLEDGMENTS

Appreciation is expressed to the leaders, state specialists, and to all others who gave so generously of their time in the development of information and in the preparation of the report. The following individuals were major contributors to the leafy green commodity assessment project:

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EXECUTIVE SUMMARY

Leafy green vegetables, including collards, kale, lettuce, mustard greens, spinach, and turnip greens, are important components of American diets. All six crops are produced for fresh market, while all except lettuce are also produced for processing. The annual value of production is about $1.2 billion, 86% of which is from lettuce production. Lettuce is produced on approximately 270,000 acres--more than the combined acreage of the other five crops. Spinach is the second largest crop, being produced on 40,000 acres. Collards, kale, mustard greens and turnip greens are produced on a total of 57,000 acres.

Plant diseases are capable of causing extensive loss of yield and quality of leafy green vegetables. Since most leafy green vegetables must be virtually blemish-free to be salable in fresh market trade, quality losses can make a portion of the crop unmarketable and result in heavy financial losses to producers. Preplant, foliar, and seed treatments of fungicides and a variety of nonchemical practices are used to prevent yield and quality losses from plant diseases. Approximately 1.5 million pounds active ingredient of fungicides are used in producing the six leafy green vegetables, ranging from 24,000 pounds on kale to 1.25 million pounds on lettuce. The loss of fungicides through EPA regulatory action, voluntary cancellation, or ineffectiveness due to resistance could cause significant economic losses.

Major Diseases

Important diseases of leafy green vegetables include Alternaria leaf spot, anthracnose, bacterial spot, black leg, black rot, blue mold, bottom rot, Cercospora leaf spot, Cercosporella leaf spot, Cladosporium leaf spot, damping-off, downy mildew, drop, Fusarium wilt, gray mold, seedling diseases, Septoria leaf spot, white mold, and white rust. Disease incidence varies greatly. In general, leaf spotting diseases were particularly troublesome in the southeastern states, while downy mildew and seedling diseases were troublesome in all states.

Use of Chemical and Nonchemical Practices

Foliar fungicides are used heavily on lettuce (93% of planted acreage), but they are used less on the other leafy greens: 55% of collards acreage, 65% of kale, 49% of mustard greens, 68% of turnip greens, and 61% of spinach (Table ES1). Foliar materials include benomyl, chlorothalonil, copper, fosetyl-Al, iprodione, maneb, metalaxyl, sulfur, and vinclozolin.

Preplant or at-planting treatments with metalaxyl are used on 1% of turnip greens acreage, 19% of lettuce acreage, and 76% of spinach acreage to control soil-borne diseases.

Seed-treatment fungicides, primarily captan and thiram, are used extensively on collards (98% of planted acres), kale (99%), mustard greens (89%), turnip greens (91%), and spinach (100%). Seed treatments are used extensively in lettuce production, except in the two largest producing

states of Arizona and California. As a result, seed treatments are used on only 7% of lettuce acreage.

The major nonchemical disease control practice is rotation, used on 94% of collards, 96% of kale, 87% of mustard greens, 91% of turnip greens, 98% of lettuce, and 91% of spinach acreage. Other practices include early harvest, trimming and sorting, raising the height of the cutter bar to leave the most heavily infected parts of plants in the field, irrigation practices, resistant varieties, and deep plowing.

Yield and Economic Impact

The loss of some fungicides would cause major impacts and the loss of others would be slight, depending upon the commodity and local conditions affecting disease development. States that experience heavy disease pressure, particularly from leaf spotting diseases, would experience much higher yield losses than those states experiencing lower disease pressure.

In general, the yield and economic losses from banning all foliar or all seed-treatment fungicides would be much larger than those from banning individual materials. The reason is that the individual chemicals have reasonably effective alternatives in many cases, but the alternatives to the entire groups, if any, are much less effective. Banning all foliar fungicides would cause the largest economic losses on collards, kale, turnip greens, lettuce, and spinach, while banning all seed treatments would cause the largest impact on mustard greens.

Foliar and Preplant Treatments

Several foliar materials and the preplant material, metalaxyl, have substantial benefits, because they fill unique niches for which alternatives are much less effective or not available. Large yield losses on current planted acres would occur with the loss of coppers on collards (13%), maneb on kale (10%), coppers on mustard greens (14%), benomyl and coppers on turnip greens (each 16%), coppers on spinach (10%), and maneb (6%) and iprodione (3%) on lettuce (Table ES1). Economic losses would range from 2 to 10% of crop value. The impact of banning the use of metalaxyl on spinach would be a yield loss of 20% and an economic loss of 19% of crop value. The loss would be greater than that of banning seed treatments on spinach and slightly less than that of banning foliar treatments.

The use of maneb for collards, kale, mustard greens, turnip greens, lettuce, and spinach was deleted from the labels of major registrants in 1989, but growers were allowed to use stocks in their possession. EPA revoked use for collards, mustard greens, turnip greens, and spinach in 1992, but reinstated use on kale and lettuce. Prior to these actions, maneb was used on 70-90% of the acreage of the crops for which use was revoked. Estimated yield losses without maneb are 21% for collards, 24% for mustard greens, 26% for turnip greens, and 17% for spinach. Economic losses to producers and consumers of these crops would be on the order of 20-25% of crop value, generally larger than the impacts of banning other single active ingredients.

The loss of all foliar materials would result in yield losses of 27% for collards, 33% for kale, 16% for mustard greens, 46% for turnip greens, 26% for lettuce, and 22% for spinach. Nonchemical alternatives, such as early harvest, raising the cutter bar, or increased trimming, would reduce yield. Economic losses would total to 11% of crop value for collards, 16% for kale, 5% for mustard greens, 20% for turnip greens, 27% for lettuce, and 24% for spinach.

Seed Treatments

The impact of banning an individual seed-treatment fungicide would be small, because these materials are good alternatives to each other in many circumstances. The loss of all seed-treatment fungicides would result in a yield loss of 10% for collards, 8% for kale, 10% for mustard greens and turnip greens, and 5% for spinach. Economic losses would sum to about 10% of crop value for all crops except lettuce, ranging from 8% for kale and spinach to 11% for turnip greens. Seed-treatment fungicides are not widely used on lettuce, and the yield and economic loss of banning them would be less than 1% of crop value (Table ES1).

Regional and Price Impacts

Bans of leafy green fungicides would generally cause proportionately larger economic losses, and discourage production more, in southern and eastern than in western regions. One exception is that the greatest impact from losing fosetyl-Al for spinach production would occur in California.

A ban of all foliar fungicides on each crop or of metalaxyl on spinach could cause production losses large enough to increase price noticeably, even after growers have adjusted input use in response to yield, cost, and short-term price changes. The result would be consumer losses and increased revenues for growers not using fungicides affected by the actions. However, growers that use affected fungicides would bear a major portion of the impact. In cases where actions have little long-term impact on price, the impacts will be concentrated on growers that use the fungicide.

Implications for the Regulatory Process

Regulatory decisions concerning seed-treatment fungicide use on leafy green vegetables, with the exception of lettuce, would be well suited to a "cluster approach," where the risk and benefits of all alternatives are considered before taking an action on any one of the alternatives. The reason is that seed treatments are very valuable in production, but the individual fungicides are good alternatives to each other in many situations. Banning one of the materials would substantially increase the benefits of the remaining alternatives. For foliar fungicides, the need for a "cluster approach" is less compelling than for seed treatments, because foliar materials often have unique niches for which cost-effective alternatives are not available. As a result, some foliar materials have substantial benefits that are independent of actions to remove alternatives. However, the comparative risks and benefits of a pesticide and its alternative practices should be considered before all regulatory decisions are made.

Table ES1. Economic impacts of bans of selected fungicides.

Treatment/ fungicide	Acres treated (%)	Yield loss/ planted acre (%)	Monetary loss ($1,000)	% of Crop value
Collards				
Foliar Treatments				
copper compounds	48	13	- 2,338	6
fosetyl-Al	5	< 1	- 229	< 1
sulfur	4	< 1	- 338	< 1
all foliar fungicides	55	27	- 4,557	11
Seed Treatments				
captan	81	0	< 1	< 1
thiram	17	1	- 740	2
all seed treatments	98	10	- 4,224	10
Kale				
Foliar Treatments				
copper compounds	6	< 1	- 103	< 1
fosetyl-Al	5	< 1	- 64	< 1
maneb	55	10	- 749	5
sulfur	3	< 1	- 106	< 1
all foliar fungicides	65	33	- 2,175	16
Seed Treatments				
captan	87	0	< 1	< 1
thiram	13	< 1	- 105	< 1
all seed treatments	99	8	- 1,084	8
Mustard Greens				
Foliar Treatments				
copper compounds	46	14	- 319	2
fosetyl-Al	3	< 1	- 79	< 1
sulfur	5	< 1	- 21	< 1
all foliar fungicides	49	16	- 657	5
Seed Treatments				
captan	73	0	< 1	< 1

Treatment/ fungicide	Acres treated (%)	Yield loss/ planted acre (%)	Monetary loss ($1,000)	% of Crop value
thiram	16	1	- 256	2
all seed treatments	89	10	- 1,438	10
Turnip Greens				
Foliar Treatments				
benomyl	50	16	- 1,962	9
copper compounds	61	16	1,402	7
sulfur	4	< 1	- 259	1
all foliar fungicides	68	46	- 4,215	20
Seed Treatments				
captan	82	0	< 1	< 1
thiram	9	1	- 404	2
all seed treatments	91	10	- 2,360	11
Preplant Treatments				
metalaxyl	1	< 1	- 11	< 1
Lettuce				
Foliar Treatments				
copper compounds	7	< 1	101	< 1
fosetyl-Al	21	< 1	1,993	< 1
iprodione	50	3	- 33,273	3
maneb	43	6	- 89,929	8
vinclozolin	33	1	- 13,247	1
all foliar fungicides	93	26	- 286,874	27
Seed Treatments				
thiram	7	< 1	- 9,657	< 1
Preplant Treatments				
metalaxyl	19	< 1	533	< 1
Spinach				
Foliar Treatments				
copper compounds	48	10	- 5,052	2
fosetyl-Al	14	6	- 4,622	5

Treatment/ fungicide	Acres treated (%)	Yield loss/ planted acre (%)	Monetary loss ($1,000)	% of Crop value
all foliar fungicides	61	22	- 19,119	24
Seed Treatments				
captan	80	0	- 2	< 1
thiram	24	< 1	- 152	< 1
all seed treatments	100	5	- 6,120	8
Preplant Treatments				
metalaxyl	76	20	- 15,581	19

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INTRODUCTION

Leafy green vegetables, including collards, kale, lettuce, mustard greens, spinach, and turnip greens, are important components of American diets. All six crops are produced for fresh market, while all except lettuce are also produced for processing. The annual value of production is about $1.2 billion, 86% of which is from lettuce production. Lettuce is produced on approximately 270,000 acres--more than the combined acreage of the other five crops. Spinach is the second largest crop, being produced on 40,000 acres. Collards, kale, mustard greens and turnip greens are produced on a total of 57,000 acres.

Plant diseases are capable of causing extensive loss of yield and quality of leafy green vegetables. Since most of the leafy green vegetables must be blemish-free to be salable in the fresh market trade, even low levels of disease can result in heavy losses to the producer.

Various disease control strategies are employed to reduce loss from plant diseases, including fungicides and nonchemical practices. Rotation is the principal nonchemical control practice employed; early harvest, trimming and sorting, raising the height of the cutter bar, irrigation practices, the use of resistant varieties and deep plowing are used less extensively by the producers of these crops. Fungicide usage as seed treatments, soil applications, and foliar sprays is extensive on leafy green vegetables. Fungicides are widely used in producing U.S. leafy greens (collards, kale, mustard greens, turnip greens, spinach and lettuce) to prevent yield losses and loss of quality from diseases.

The purpose of this study was to determine the effect on leafy green vegetable production of the withdrawal of individual and groups of fungicides. For purposes of analysis and explanation, we also collected data on the economically important diseases, fungicide usage, and nonchemical disease management practices.

METHODOLOGY

In September of 1992, under a grant from the NAPIAP, a team of scientists from State Extension Services and Agricultural Experiment Stations was selected to conduct the assessment of the disease management techniques used on collards, kale, mustard greens, turnip greens, spinach and lettuce. The members of this team were selected based on their expertise with the pest management practices and geographic production regions in which these crops are grown. The scientific team met regionally in October and November, 1992, to discuss the assessment and to develop the survey forms necessary to gather data from those production areas with significant crop acreage. The questionnaire requested the following information for each crop: (1) number of acres planted annually for the period 1987 to 1992; (2) production levels over the same period; (3) the percent of planted acres treated with individual fungicides in 1992; (4) application data for 1992 [number of treatments, rate employed, timing]; (5) pests controlled by each treatment; (6) estimated change in acres treated if specific fungicides and fungicide groups were not available, along with the expected alternatives; and (7) estimated change in yield or quality should specific fungicides and fungicide groups become unavailable. Each scientist was then asked to complete the necessary forms for their respective crops and regional areas. Expert opinion was employed during this pesticide use assessment when empirical data on usage and pest loss were not available.

RESULTS

DISEASE CONTROL STRATEGIES AND THE IMPACT OF THEIR WITHDRAWAL ON COLLARDS

by

John K. Springer

Collards are grown in the United States on over 21,400 acres with an average yield of over 12,000 pounds of greens/acre (Table C1). Approximately 259 million pounds of greens are produced in a normal year with a value of over $41 million.

Table C1. Acres planted, yield and value of U.S. production for collards.

State[1]	Planted acres[2]	Yield/acre (lb greens)	Yield/state (1,000 lb)	Values ($)[3] (100 lb)	Value ($)[3] per state
Alabama	1,974	12,000	23,688	20.00	4,737,600
Arizona	800	13,000	10,400	17.00	1,768,000
California	1,022	20,000	20,440	25.00	5,110,000
Florida	1,500	20,000	30,000	17.50	5,250,000
Georgia	8,455	8,750	73,981	4.60	3,403,138
Maryland	511	11,000	5,621	39.00	2,192,190
North Carolina	2,200	11,500	25,300	26.00	6,578,000
New Jersey	913	12,000	10,956	21.00	2,300,760
New York	200	18,000	3,600	20.00	720,000
Ohio	230	20,000	4,600	30.00	1,380,000
Oklahoma	375	16,000	6,000	5.70	342,000
Pennsylvania	400	17,000	6,800	26.00	1,768,000
South Carolina	1,350	11,500	15,525	18.00	2,794,500
Tennessee	600	12,000	7,200	6.00	432,000
Texas	300	20,000	6,000	4.00	240,000
Virginia	600	15,000	9,000	26.00	2,340,000
U.S. Totals (of states reporting)	21,430	12,091	259,111	16.00	41,356,187

[1] Washington state produced seed (1,700 lb/acre) but no greens on 300 acres
[2] Acres that were planted once/year were counted once. Acres planted 2 times/year were counted as 2 acres, etc.
[3] Value ($) of greens to the producer in terms of receipts for the product.

The most important diseases of collards for which control measures are directed include downy mildew (*Peronospora parasitica*), black rot (*Xanthomonas campestris*), Alternaria leaf spot (*Alternaria brassicicola* and *A. brassicae*) and seedling diseases (*Pellicularia filamentosa*, *Pythium* spp. and *Phytophthora* spp.). Seed producers in Washington state also experience trouble with white mold (*Sclerotinia sclerotiorum*). Downy mildew, black rot, Alternaria leaf spot and seedling diseases are serious problems in both the more humid and less humid regions of the country.

As with all of the leafy greens, the leaves must be blemish-free to be sold for fresh market use. Fields that are too heavily infected are abandoned. The value of the crop for fresh market ranges between 20 and 39 cents a pound and the value for the processing crop ranges between 4 and 6 cents a pound. Thus, even a low level of disease can result in extensive loss to the producer. Georgia, Oklahoma, Tennessee, and Texas produce collards principally for the processing market. The other states produce the crop principally, or exclusively, for the fresh market.

The fungicides used on collards in U.S. production are listed in Table C2 with the acres treated, use pattern, and pounds of ai used. Copper-containing fungicides were the most commonly used foliar fungicide with almost 10,000 acres treated and over 35,000 pounds of ai used. An additional 575 acres are treated with a combination of copper plus sulfur with 500 pounds of ai copper applied. Copper is used for downy mildew control and for leaf spot control. It is relatively weak on leaf spot control under heavy disease pressure. Fosetyl-Al was the second most commonly used foliar fungicide, and it was used on almost 1,180 acres with over 2,400 pounds of ai applied. It is used for downy mildew control and has a very narrow spectrum of activity. Since fosetyl-Al has just recently received label clearance for use on collards, the use of this material may increase if it proves economically viable. Sulfur was the third most commonly used foliar fungicide with 296 acres treated and nearly 2,000 pounds of ai applied when used alone. An additional 575 acres are treated with a combination of copper

Table C2. Fungicide use in U.S. collards production.

Fungicide	Treated acres	Use pattern[1]	Fungicide use lb ai
benomyl	230	ST	0.1
captan	17,415	ST	34.8
copper	9,756	F	35,181.2
copper + sulfur	575	F	500 + 3,131.0
fosetyl-Al	1,175	F	2,464.5
sulfur	296	F	1,946.0
thiram	3,660	ST	11.0
U.S. Total (of states reporting)			43,268.6

[1] F = foliar, ST = seed treatment

plus sulfur with 3,131 pounds of ai sulfur applied. Sulfur is combined with copper to provide improved leaf spot control and to permit the use of lower rates of copper to reduce phytotoxicity. It is also used alone on limited acreage for powdery mildew and Alternaria leaf spot control. Captan and thiram were used on extensive acreage as a seed treatment, but the total pounds of ai used was only 34 and 11 pounds, respectively. Captan and thiram seed treatments are used to control seedling diseases. Benomyl was used in only one state as a seed treatment on 230 acres with 0.1 pound of ai used, principally for seedling disease control.

Growers can reduce loss from disease by utilizing several nonpesticide practices. They may harvest prematurely when the crop is relatively disease-free with a reduction in yield of 5 to 10%. The reduced yield may be balanced by eliminating one fungicide spray. Growers can sort out the disease-infected leaves and discard this portion of the crop with a reduction in yield from 5 to 25%. In fact, North Carolina uses this method exclusively. Instead of using foliar fungicides, they overplant and discard infected leaves. Because their market is entirely fresh, they can afford the hand labor required to sort the leaves. Growers may also raise the cutter-bar height to leave the more heavily infected lower portion of the leaves in the field with a reduction in yield of 10 to 25%, depending on how high the cutter bar is set. All three of these nonchemical means of reducing disease losses may be suitable for the fresh market crop, but sorting is not an economically feasible practice for the processing crop because of the low value of the crop for this market.

Rotation, as practiced on almost 94% of the acreage, is utilized to assist in the control of seedling diseases, Alternaria leaf spot and black rot, and is the major nonpesticide control practice used on collards (Appendix, Table 4). Rotation reduces disease pressure by reducing inoculum levels, which permits other control strategies to be more effective. The normal rotational scheme is one year without planting collards or a related crop before replanting this crop. The seed producers plant collards or a related crop once every three years, with two years in noncrucifer crops.

The impact of withdrawing individual pesticides from use is highly variable (Table C3). The greatest impact would result from the loss of copper with a loss of over 33 million pounds of greens when used alone. An additional loss of almost 2 million pounds of greens would occur

Table C3. Impact of loss of individual fungicides on U.S. collards production.

Fungicide lost	% Acres currently treated	% Yield impact on planted acres when alternatives are used	Yield impact lb leaf
benomyl	1.07	0.00	0
captan	81.26	0.00	0
copper	45.53	- 12.80	- 33,161,040
copper + sulfur	2.68	- 0.74	- 1,923,000
fosetyl-Al	5.48	- 0.94	- 2,440,831
sulfur	1.38	- 0.25	- 634,838
thiram	17.08	- 1.10	- 2,846,250

with the loss of the copper plus sulfur combination. Fosetyl-Al would replace copper for downy mildew control in many states. However, it has performed erratically in some other states and would not be used in these states. The increased production cost associated with the use of fosetyl-Al will restrict its use in some states. The second most critical fungicide is thiram seed treatment, with a loss of over 2.8 million pounds of greens if this fungicide use pattern were withdrawn. Captan would replace thiram. The third most critical fungicide is fosetyl-Al, with a loss of over 2.4 million pounds of greens with the loss of this fungicide. The only suitable alternative fungicide to fosetyl-Al is copper, which can be quite phytotoxic. The fourth most critical fungicide loss would be sulfur, with a loss of almost 0.6 million pounds of greens when used alone. An additional loss of almost 2 million pounds of greens would occur with the loss of the sulfur plus copper combination. The principal use of sulfur is in a combination product containing copper and sulfur. The combination of copper and sulfur results in better leaf spot control than either compound individually. Copper alone or fosetyl-Al would substitute for sulfur if this use pattern were lost. There would be no significant economic loss with the loss of either benomyl or captan seed treatments, as long as thiram retained its label for seed-treatment purposes on collards. The use of benomyl as a seed treatment is principally for black leg control. The label for benomyl was originally issued over 20 years ago when many of the crucifer seed lots became contaminated with *Phoma lingam*, the causal agent of black leg. Since the seed has been free of this pathogen for many years, the loss from eliminating this seed treatment would probably be minimal.

Maneb was the principal fungicide used on collards prior to the deletion of this use pattern from the label, with almost 72% of the acres treated. The percentage and number of acres treated prior to the loss of this fungicide and the estimated current yield reduction from its loss are presented in Table C4. In addition to the reported losses, many states indicated that acreage decreases have occurred and will continue to occur. The principal reasons given were increased production costs from the use of more expensive fungicides, phytotoxicity of copper-containing fungicides and generally poorer control of various leaf spotting diseases with presently labeled fungicides. Although the loss of yield and acreage has been substantial in many states, maneb is perceived to be a liability in some states because of negative public perception and would not be used even if this use pattern were reinstated. However, other states feel that reinstating the maneb label would be the salvation of the industry in their respective states. The loss of maneb has had an estimated 21% impact on yield, with a loss of over 55 million pounds of greens. Georgia has recently received a local label for the use of chlorothalonil on collards, mustard greens and turnip greens for downy mildew and Alternaria leaf spot control. Because the label was received after data for this report were collected, data for chlorothalonil usage in Georgia are not included. Thus, Georgia becomes the first state to possess a nonphytotoxic, preventative-type, labeled fungicide to assist in managing fungicide resistance. The longer residual activity of chlorothalonil will also provide late season control of leaf spot, resulting in lower yield losses from these diseases. Further, this use pattern may lessen the economic impact of the loss of maneb on leafy green commodities where it is labeled.

The data for collards seed production are presented in the Appendix, Tables 1 to 4. Fosetyl-Al, coppers and sulfur are not utilized in the seed production crop. Local use labels for two formulations of iprodione have been secured and this fungicide is used on 100% of the acreage. Iprodione is used principally for white mold and Alternaria leaf spot control. A combination seed treatment of thiram plus metalaxyl is used on 100% of the seed planted, principally for seedling disease control. Collards are planted on the same land no more frequently than once

Table C4. Impact of loss of maneb on U.S. collards production.

State	Treated when labeled		% Yield impact on planted acres	Yield impact lb leaf
	% acres	acres		
Alabama	50	987	- 10	- 1,184,400
Arizona	50	400	- 10	- 520,000
California	100	1,022	- 10	- 2,044,000
Florida	60	900	- 30	- 5,400,000
Georgia	100	8,455	- 55	- 40,689,687
Maryland	30	153	- 15	- 252,450
North Carolina	10	220	- 10	- 253,000
New Jersey	90	822	- 10	- 986,400
Ohio	30	69	- 10	- 138,000
Oklahoma	30	113	- 1	- 18,080
Pennsylvania	30	120	- 10	- 204,000
South Carolina	75	1,013	- 15	- 1,747,425
Tennessee	80	480	- 15	- 864,000
Texas	80	240	- 10	- 480,000
Virginia	60	360	- 10	- 540,000
Washington	100[1]	300[1]	- 10[1]	[2]
U.S. Totals (of states reporting)	71.6	15,354	21.4	- 55,321,442

[1] Values not included in U.S. totals
[2] Loss of 10% of the seed produced (51,000 lb @ $0.45/lb)

every three years in the seed production industry for control of seedling diseases and suppression of white mold.

Loss of iprodione for the seed crop would result in a loss of 30% of the collards seed produced (153,000 pounds seed) and no suitable fungicide replacement is available. Loss of the metalaxyl and thiram seed treatment would result in a yield reduction of 6% (30,600 pounds seed). Captan could substitute for thiram, but there is no alternative fungicide for metalaxyl. Loss from the removal of all foliar fungicide labels is identical to that for the loss of iprodione, since this is the only foliar fungicide used. And loss of all seed-treatment fungicides would be identical to loss of the metalaxyl plus thiram seed treatment.

The loss of groups of fungicides on the edible crop is presented in Table C5. The loss of all foliar fungicides would result in a loss of almost 27% of the crop (over 69 million pounds). The loss of all seed-treatment fungicides would have a less profound, but significant, impact (10% with a loss of over 25 million pounds) and the impact would vary considerably among the states.

In general, in states where the crop is planted into cooler soils, the impact of the loss of seed-treatment chemicals would be more critical.

Table C5. Impact of loss of fungicide groups on U.S. collards production.

Fungicide group lost	% Acres currently treated	% Yield impact on planted acres	Yield impact lb leaf
Foliar fungicides	54.6	- 26.8	- 69,332,403
Seed treatments	98.3	- 9.9	- 25,738,700

Detailed information for individual states is included in the Appendix, Tables 1 to 4.

DISEASE CONTROL STRATEGIES AND THE IMPACT OF THEIR WITHDRAWAL ON KALE

by

John K.Springer

Kale is grown in the United States on about 7,200 acres with an average yield of over 13,200 pounds of greens/acre (Table K1). Over 95 million pounds of greens are produced in a normal year with a value of almost $14 million.

Table K1. Acres planted, yield and value of U.S. production for kale.

State[1]	Planted acres[2]	Yield/acre (lb greens)	Yield/state (1,000 lb)	Values ($)[3] (100 lb)	Value ($)[3] per state
Arizona	188	10,787	2,028	21.00	425,871
California	804	21,000	16,884	25.00	4,221,000
Florida	341	11,000	3,751	15.50	581,405
Georgia	2,610	11,250	29,363	4.80	1,409,400
Maryland	615	9,500	5,843	19.00	1,110,075
North Carolina	500	11,000	5,500	17.00	935,000
New Jersey	433	11,000	4,763	20.00	952,600
New York	75	18,000	1,350	20.00	270,000
Ohio	155	21,000	3,255	29.00	943,950
Oklahoma	140	16,000	2,240	5.00	112,000
Pennsylvania	200	17,000	3,400	25.00	850,000
South Carolina	140	11,500	1,610	33.00	531,300
Tennessee	70	12,000	840	5.00	42,000
Texas	400	23,000	9,200	3.00	276,000
Virginia	500	10,000	5,000	26.00	1,300,000
U.S. Totals (of states reporting)	7,171	13,251	95,026	14.70	13,960,601

[1] Washington state produced seed (1,200 lb/acre) but no greens on 400 acres
[2] Acres that were planted once/year are counted once. Acres planted 2 times/year were counted as 2 acres, etc.
[3] Value ($) of greens to the producer in terms of receipts for the product.

The most important diseases of kale for which control measures are directed include downy mildew (*Peronospora parasitica*), black rot (*Xanthomonas campestris*), Alternaria leaf spot (*Alternaria brassicicola* and *A. brassicae*) and seedling diseases (*Pellicularia filamentosa*, *Pythium* spp. and *Phytophthora* spp.). Seed producers in Washington state also experience trouble with white mold (*Sclerotinia sclerotiorum*). Downy mildew, black rot, Alternaria leaf spot and seedling diseases are serious problems in both the more humid and less humid regions of the country.

The fungicides used on kale in U.S. production are listed in Table K2 with the acres treated, use pattern, and pounds of ai used. Maneb was the most heavily used foliar fungicide with over 3,900 acres treated and over 20,600 pounds of ai used. It is used principally for downy mildew and leaf spot control and is the most economical fungicide to use. Copper was the second most commonly used foliar fungicide with 270 acres treated with copper alone and 140 acres treated with copper plus sulfur. A total of over 630 pounds of ai copper was applied. The addition of sulfur to copper permits lower rates of copper to be used and reduces the phytotoxicity that copper can produce. The combination also provides somewhat better leaf spot control than either material used alone. Fosetyl-Al was the third most commonly used foliar fungicide and it was used on 360 acres with over 1,320 pounds of ai applied. It is used principally for downy mildew control, but has some activity in leaf spot control. Sulfur was applied on only 40 acres by itself, with 322 pounds of ai used. It was also applied on 140 acres in combination with copper and 876 pounds of ai sulfur was used. Its principal use was for leaf spot control. Captan and thiram were used on extensive acreage as a seed treatment, and the pounds of ai used were 18.6 and 3.6 pounds, respectively. Captan and thiram seed treatments are used for seedling disease control. Benomyl was used in only one state as a seed treatment on 155 acres, with almost 0.2 pounds of ai used. It is used for black leg and seedling disease control on this limited acreage.

Table K2. Fungicide use in U.S. kale production.

Fungicide	Treated acres	Use pattern[1]	Fungicide use lb ai
benomyl	155	ST	0.16
captan	6,209	ST	18.63
copper	270	F	497.40
copper + sulfur	140	F	140 + 876.40
fosetyl-Al	360	F	1,325.92
maneb	3,916	F	20,631.10
sulfur	40	F	322.00
thiram	913	ST	3.65
U.S. Total (of states reporting)			23,815.26

[1] F = foliar, ST = seed treatment

As with all of the leafy greens, kale leaves must be blemish-free to be sold for fresh market use. Fields that are too heavily infected are not harvested. Even so, foliar fungicides are not used in North Carolina. Instead, farmers discard leaves, plants or whole fields that are infected. They deliberately overplant to make up this deficit, and they minimize costs by planting after field corn, thereby avoiding additional rent and utilizing the residual field corn fertilizer. All of their production is for fresh market, so they can afford hand labor to sort out infected leaves. Since the value of the crop for fresh market ranges between 20 and 33 cents a pound and the

value for the processing crop ranges between 3 and 5.85 cents a pound, even a low level of disease can result in extensive loss to the producer. Georgia, Oklahoma, Tennessee, and Texas produce kale principally for the processing market. The other states produce kale principally, or exclusively, for the fresh market.

Nonpesticide control measures for reducing loss from disease include (1) harvesting prematurely when the crop is relatively disease-free with a yield reduction of 5 and 10%, but which saves one fungicide spray, (2) sorting leaves in order to discard infected leaves that can reduce yields from 5 to 25%, and/or (3) raising the cutter-bar height to leave many of the more heavily infected lower portions of the leaves in the field with a yield reduction of 10-25%. All three of the above practices are suitable for the fresh market crop, while premature harvest and raising the cutter bar may be feasible for the processing crop. The low value of the crop for processing precludes the practice of sorting for this market.

Rotation, as practiced on over 96% of the acreage (6,913 acres), is utilized to assist in the control of seedling diseases, Alternaria leaf spot and black rot, and is the major nonpesticide control practice used on kale (Appendix, Table 8). Rotation reduces disease pressure by reducing the inoculum level, which permits other control strategies to be more effective. Rotation by most growers consists of planting kale no more frequently than once in any two-year period. Seed producers plant kale no more frequently than one year in any three-year period.

The impact of withdrawing individual pesticides from use is highly variable (Table K3). The greatest impact would result from the loss of maneb, with a loss of almost 10 million pounds of greens. Maneb is used principally for downy mildew and leaf spot control. The only suitable fungicide replacements for downy mildew control are fosetyl-Al and coppers and neither of these is as effective for leaf spot control. Fosetyl-Al is too costly to replace a high percentage of the acres treated with maneb for the processing crop, but is suitable for the fresh market crop in some regions. Coppers are, in general, too phytotoxic to replace maneb; the injury from phytotoxicity produces almost as serious a problem as the injury produced by the disease. The second most critical fungicide used on kale is thiram seed treatment, with an expected loss of almost 620,000 pounds of greens, if it were removed. This loss is restricted to one state, North Carolina, where the alternative seed treatment, captan, would replace thiram. The third most critical fungicide is the combination of copper plus sulfur with a loss of almost 293,000 pounds of greens. The loss would occur in only one state, Ohio, and fosetyl-Al would replace this combination. The fourth most critical fungicide is fosetyl-Al with a loss of over 283,100 pounds of greens. Maneb would substitute for fosetyl-Al if it were lost in most states, but it would be replaced by copper plus sulfur in Ohio where maneb has a negative public perception problem and would not be used. The loss of either copper or sulfur individually would result in a loss of less than 100,000 pounds of greens for each fungicide, but would result in a loss of almost 300,000 pounds of greens with the loss of the copper plus sulfur combination. Both would probably be replaced by maneb, except in areas where maneb has a perception problem, where they would be replaced by fosetyl-Al. Since fosetyl-Al has just recently been labeled, this foliar fungicide could become more important in the production of kale, at least for the fresh market. There would be no economic loss with the loss of either benomyl or captan seed treatments as long as thiram retained its label for seed-treatment purposes. Benomyl is used as a seed treatment principally for black leg and seedling disease control. The label for benomyl originally was issued over 20 years ago when many of the crucifer seed lots became contaminated with *Phoma lingam*, the causal agent of black leg. Since the seed has been free

of this pathogen for many years, the loss from eliminating this seed treatment would probably be minimal.

The data for kale seed production are presented in the Appendix, Tables 5 to 8. Fosetyl-Al, coppers and sulfur are not utilized in the seed production crop. Local use labels for two formulations of iprodione have been secured and this fungicide is used on 100% of the acreage, principally for white mold and Alternaria leaf spot control. No fungicide replacement is available for iprodione that is effective for white mold, and a loss of 25% of the seed crop (120,000 pounds seed) would result with the withdrawal of this label. Maneb is used on 10% of the seed crop acreage, principally for downy mildew and Alternaria leaf spot control. No fungicide would be a suitable replacement for maneb, and a loss of 5% on the treated acres (2,400 pounds seed) would occur if the maneb label were withdrawn. A combination seed treatment of thiram plus metalaxyl is used on 100% of the kale grown for seed for seedling disease control. Captan would replace thiram if its label were withdrawn and no loss in yield would occur. There is no alternative fungicide for metalaxyl seed treatment and a loss of 5% would occur if this label were lost (24,000 pounds seed). Seed producers plant kale fields no more frequently than one year in each three-year period on the same land for control of seedling diseases and suppression of white mold.

Table K3. Impact of loss of individual fungicides on U.S. kale production.

Fungicide lost	Acres currently treated	% Yield impact on planted acres when alternatives are used	Yield impact lb leaf
benomyl	155	0.0	0
captan	6,209	0.0	0
copper	270	- 0.1	- 95,731
copper + sulfur	140	- 0.3	- 292,950
fosetyl-Al	360	- 0.3	- 283,144
maneb	3,916	- 10.2	- 9,725,163
sulfur	40	- 0.1	- 84,420
thiram	913	- 0.7	- 618,750
iprodione	400[1]	- 25.0[1]	[2]

[1] Used in seed production fields
[2] Loss of 25% of seed crop (120,000 lb seed @ $0.70/lb)

The withdrawal of all foliar fungicides for the seed crop would result in a loss of 25.5% of the kale seed produced (122,400 pounds seed). The loss of all seed-treatment fungicides for the seed crop would result in a loss of 5% (24,000 pounds seed).

The loss of groups of fungicides, except for seed producers, is presented in Table K4. The withdrawal of all foliar fungicide labels would result in a loss of over 33% of the crop (over 31.6 million pounds of greens), while the withdrawal of all seed-treatment fungicide labels would result in a loss of almost 8% of the crop (almost 7.5 million pounds of greens).

Table K4. Impact of loss of fungicide groups on U.S. kale production.

Fungicide group lost	% Acres currently treated	% Yield impact on planted acres	Yield impact lb leaf lost
Foliar fungicides	64.9	- 33.33	- 31,605,249
Seed treatments	99.3	- 7.84	- 7,450,002

Detailed information for individual states is included in the Appendix, Tables 5 to 8.

DISEASE CONTROL STRATEGIES AND THE IMPACT OF THEIR WITHDRAWAL ON MUSTARD GREENS

by

John K. Springer

Mustard greens are grown in the United States on about 9,800 acres with an average yield of almost 11,800 pounds of greens/acre (Table MG1). Approximately 115 million pounds of greens are produced in a normal year with a value of almost $14 million.

Table MG1. Acres planted, yield and value of U.S. production for mustard greens.

State[1]	Planted acres[2]	Yield/acre (lb greens)	Yield/state (1,000 lb)	Values ($)[3] (100 lb)	Value ($)[3] per state
Alabama	847	10,500	8,894	20.00	1,778,700
Arizona	200	11,000	2,200	17.00	374,000
California	253	20,000	5,060	30.00	1,518,000
Florida	400	18,000	7,200	15.50	1,116,000
Georgia	3,549	11,750	41,701	2.20	917,417
Maryland	200	8,000	1,600	39.00	624,000
North Carolina	1,200	11,000	13,200	17.25	2,277,000
New Jersey	500	10,500	5,250	20.00	1,050,000
New York	75	18,000	1,350	20.00	270,000
Ohio	235	16,050	3,772	30.00	1,131,525
Oklahoma	350	16,000	5,600	7.40	414,400
Pennsylvania	100	10,000	1,000	20.00	200,000
South Carolina	300	8,200	2,460	32.00	787,200
Tennessee	1,000	7,000	7,000	6.00	420,000
Texas	300	18,000	5,400	3.00	162,000
Virginia	300	12,000	3,600	26.00	936,000
U.S. Totals (of states reporting)	9,809	11,753	115,286	12.10	13,976,242

[1] Washington state produced seed (1,500 lb/acre) but no greens on 300 acres
[2] Acres that were planted once/year were counted once. Acres planted 2 times/year were counted twice, etc.
[3] Value ($) of greens to the producer in terms of receipts for the product.

The most important diseases of mustard greens for which control measures are directed include downy mildew (*Peronospora parasitica*), black rot (*Xanthomonas campestris*), seedling diseases (*Pellicularia filamentosa*, *Pythium* spp. and *Phytophthora* spp.) and various leaf spotting

diseases caused by *Alternaria brassicicola*, *A. brassicae*, *Cercospora albomaculans*, *Cercosporella brassicae* and *Colletotrichum higginsianum*. Seed producers in Washington state also experience trouble with white mold (*Sclerotinia sclerotiorum*). Downy mildew, black rot, Alternaria leaf spot and seedling diseases are serious problems in both the more humid and less humid regions of the country. Anthracnose, Cercospora leaf spot and Cercosporella leaf spot can occur throughout the country, but they are major causes of loss in warm, humid regions. These diseases are the major cause of disease loss in the southeastern region of the country.

The fungicides used on mustard greens in U.S. production are listed in Table MG2 with the acres treated, use pattern, and pounds of ai used. Copper-containing fungicides were the most commonly used foliar fungicide with over 4,100 acres treated and over 19,300 pounds of ai used. Copper is also used in combination with sulfur and this combination was used on 410 acres, with 503 pounds of ai copper applied. Copper is used for downy mildew, anthracnose, Alternaria leaf spot, Cercospora leaf spot and black rot control. The only alternative for copper for downy mildew control is fosetyl-Al, which is considerably more expensive and is even less effective for some of the leaf spotting diseases. Sulfur was the second most commonly used foliar fungicide with 30 acres treated and 240 pounds of ai applied when used alone. It was also applied on 410 acres in combination with copper and 3,149 pounds of ai sulfur was used. About one-quarter of the states use sulfur in combination with copper for enhanced leaf spot control. There is no suitable replacement for sulfur when used alone. In the states where the copper plus sulfur combination was used, most reported that no suitable replacement fungicide is available. Ohio reported that 100% of the acreage treated with the combination would be treated with fosetyl-Al. Fosetyl-Al was the third most commonly used foliar fungicide with almost 300 acres treated and over 900 pounds of ai used. Fosetyl-Al is used principally for downy mildew control, but this fungicide also provides good Alternaria leaf spot control. If fosetyl-Al were lost, some states report that no suitable replacement is available, and other states would substitute with copper or copper plus sulfur. Captan was used on extensive mustard greens acreage (7,159 acres) as a seed treatment and 72 pounds of ai were used, while thiram was used on almost 1,600 acres as a seed treatment and 16 pounds of ai were used. Both captan and thiram seed treatments are used to provide seedling disease control. Each would substitute for the other if the labeled use pattern for either one were withdrawn.

As with all of the leafy greens, the leaves must be blemish-free to be sold for fresh market use. Fields too heavily infected with disease are not harvested. Even so, foliar fungicides are not used in North Carolina. Instead, farmers discard leaves, plants or whole fields that are infected. They deliberately overplant to make up this deficit, and they minimize costs by planting after field corn, thereby avoiding additional rent and utilizing the residual field corn fertilizer. All of their production is for fresh market, so they can afford hand labor to sort out infected leaves. The value of the crop for fresh market in the U.S. ranges between 17 and 39 cents a pound, and the value for the processing crop ranges between 2.2 and 6 cents a pound. Georgia, Oklahoma, Tennessee, and Texas produce mustard greens principally for the processing market. The other states produce the crop principally, or exclusively, for the fresh market.

Nonpesticide means of reducing loss from disease include premature harvest when the crop is relatively disease-free, the harvested crop can be sorted and the disease-infected leaves discarded, or the cutter bar can be raised to leave many of the more heavily infected lower portion of the leaves in the field. Use of any of these options can reduce yield by 5-25%.

Rotation, as practiced on over 87% of the acreage, is utilized to assist in the control of seedling diseases, the various leaf spotting diseases and black rot. It is the major nonpesticide control practice used on mustard greens (Appendix, Table 12). Rotation reduces disease pressure by reducing inoculum levels, which permits other control strategies to be more effective. The normal length of the rotational scheme practiced is once in any two-year period, except for the seed producers who plant once in any three-year period.

Table MG2. Fungicide use in U.S. mustard greens production.

Fungicide	Treated acres	Use pattern[1]	Fungicide use lb ai
captan	7,159	ST	72
copper	4,137	F	19,333
copper + sulfur	410	F	503 + 3,149
fosetyl-Al	294	F	909
sulfur	30	F	240
thiram	1,568	ST	16
U.S. Total (of states reporting)			24,221

[1] F = foliar, ST = seed treatment

The impact of withdrawing individual pesticides from use is highly variable (Table MG3). Copper is the most critical fungicide used on mustard greens, with an expected loss of over 15 million pounds of greens. The main uses for coppers on mustard greens are for downy mildew and the various leaf spotting diseases. It can be phytotoxic, however, and it is only moderately effective for control of the leaf spotting diseases, particularly in the southeastern region of the country. In regions of the country where weather conditions are highly conducive to leaf spotting diseases, copper does not provide adequate control. The only alternative to copper is fosetyl-Al, which is quite effective in most states. Many states, however, do not feel that fosetyl-Al is a cost-effective alternative, particularly for the processing crop. Georgia has recently received a local label for the use of chlorothalonil for leaf spot control, but the data are not shown in the tables because data were not available at the time of the survey. Control of the leaf spotting diseases should be adequate with chlorothalonil, but its use will increase production costs. The second most critical foliar fungicide is fosetyl-Al, with a loss of 330,000 pounds of greens if it were lost. Fosetyl-Al is used principally for downy mildew control and its replacement would be copper, a material that possesses the potential for phytotoxicity. The third most critical foliar fungicide is the combination of copper plus sulfur, with a loss of almost 130,000 pounds of greens. The loss of either copper or sulfur would result in the loss of this combination. Most states where this combination is used indicate that there is no suitable replacement; Ohio growers would substitute fosetyl-Al. The withdrawal of the label for sulfur applied alone would result in a loss of about 12,000 pounds of greens. An additional loss of 128,000 pounds of greens would occur from the loss of the copper plus sulfur combination. Sulfur is generally used in combination with copper for downy mildew and leaf spot control.

If sulfur were lost, most of the acreage sprayed would receive fosetyl-Al, and the remaining acreage would not be sprayed with an alternative fungicide. This would reduce the level of leaf spot control in acres treated with alternatives. There would be no yield loss with the loss of captan seed treatments as long as thiram retained its label for seed-treatment purposes. Removing the thiram seed-treatment label would result in a loss of almost 1.5 million pounds of greens. This loss would occur in only one state, North Carolina, where growers would switch to a captan seed treatment.

Table MG3. Impact of loss of individual fungicides on U.S. mustard greens production.

Fungicide lost	% Acres currently treated	% Yield impact on planted acres when alternatives are used	Yield impact lb leaf
captan	73.0	0.00	0
copper	42.2	- 13.40	- 15,463,616
copper + sulfur	4.2	- 0.10	- 128,000
fosetyl-Al	3.0	- 0.30	- 330,420
sulfur	0.3	< - 0.01	- 12,300
thiram	16.0	- 1.30	- 1,485,000

The data for mustard greens seed production are presented in the Appendix, Tables 9 to 12. Copper, sulfur and fosetyl-Al are not utilized in the seed production crop. Local use labels for benomyl, metalaxyl and chlorothalonil have been secured, and these fungicides are used on 100%, 50% and 100% of the acreage, respectively. The principal use for benomyl is for white mold and Alternaria leaf spot control. There is no suitable fungicide replacement for benomyl to control white mold, and withdrawal of this label would result in a loss of 30% of the seed produced (135,000 pounds seed). The principal use for metalaxyl is for downy mildew control, and chlorothalonil would replace metalaxyl if this label were withdrawn, with a loss of 20% of the seed crop on the acres treated (45,000 pounds seed). Chlorothalonil is used for downy mildew and Alternaria leaf spot control, and metalaxyl would replace chlorothalonil for downy mildew control, with a loss of 10% of the seed crop (45,000 pounds seed). Captan is used on 100% of the acres as a seed treatment for Rhizoctonia and Pythium root rot control. Thiram would replace captan if its label were withdrawn and no yield loss would occur. Seed producers plant mustard greens fields no more frequently than one year in every five-year period on the same land for control of seedling diseases and suppression of white mold.

Withdrawal of all foliar fungicide labels for the seed crop would result in a loss of 50% (225,000 pounds seed) of the crop. Withdrawal of all seed-treatment fungicide labels would result in a loss of 5% (22,500 pounds seed).

Maneb was the principal fungicide used on mustard greens prior to its withdrawal. The percentage and number of acres treated prior to the loss of this fungicide and the estimated current yield reduction from its loss are presented in Table MG4. In addition to the reported yield losses, many states indicated that acreage decreases have occurred and will continue to

occur. The principal reasons given were increased production costs from use of more expensive fungicides, phytotoxicity of copper-containing fungicides and generally poorer control of various leaf spotting diseases with presently labeled fungicides. Maneb's use was rated as a critical need in almost all of the southeastern states. The relative ineffectiveness of coppers for leaf spot control and the yield reduction associated with techniques used to sort healthy leaves from diseased leaves were cited as reasons for this loss. The local label for use of chlorothalonil in Georgia will permit an enhanced level of leaf spot control but will increase fungicide costs. However, the net effect will be positive, since yield reductions from leaf spotting diseases can exceed 50% in southeastern states.

Table MG4. Impact of loss of maneb on U.S. mustard greens production.

State	Treated when labeled		% Yield impact on planted acres	Yield impact lb leaf
	% acres	acres		
Alabama	50	424	- 10	- 445,200
Arizona	50	100	- 10	- 110,000
California	100	253	- 15	- 759,000
Florida	60	240	- 40	- 1,728,000
Georgia	98	3,478	- 50	- 20,433,250
Maryland	40	80	- 10	- 64,000
North Carolina	50	600	- 10	- 660,000
New Jersey	75	375	- 10	- 393,750
Ohio	25	59	- 10	- 94,695
Oklahoma	25	88	- 15	- 211,200
Pennsylvania	50	50	- 10	- 50,000
South Carolina	25	75	- 10	- 61,500
Tennessee	80	800	- 35	- 1,960,000
Texas	100	300	- 10	- 540,000
Virginia	90	270	- 5	- 162,000
Washington	100[1]	300[1]	- 15[1]	[2]
U.S. Totals (of states reporting)	73.3	7,192	- 24.0	- 27,627,595

[1] Values not included in U.S. totals
[2] Loss of 15% of the seed produced (67,500 lb @ $0.50/lb)

The loss of groups of fungicides for the edible crop is presented in Table MG5. Withdrawal of all foliar fungicide labels would result in a loss of over 16% of the crop (almost 19 million pounds), while the withdrawal of all seed-treatment fungicide labels would result in a loss of over 9% of the crop (almost 11 million pounds). The impact would vary considerably among

the states. In general, in states where the crop is planted into cooler soils, the impact of the loss of seed-treatment chemicals would be most critical.

Table MG5. Impact of loss of fungicide groups on U.S. mustard greens production.

Fungicide group lost	% Acres currently treated	% Yield impact on planted acres	Yield impact lb leaf
Foliar fungicides	48.5	- 16.3	- 18,830,395
Seed treatments	88.6	- 9.5	- 10,917,450

Detailed information for individual states is included in the Appendix, Tables 9 to 12.

DISEASE CONTROL STRATEGIES AND THE IMPACT OF THEIR WITHDRAWAL ON TURNIP GREENS

by

John K. Springer

Turnip greens are grown in the United States on about 18,600 acres with an average yield of over 12,500 pounds of greens/acre (Table TG1). Approximately 233 million pounds of greens are produced in a normal year with a value of almost $21 million.

Table TG1. Acres planted, yield and value of U.S. production for turnip greens.

State[1]	Planted acres[2]	Yield/acre (lb greens)	Yield/state (1,000 lb)	Values ($)[3] (100 lb)	Value ($)[3] per state
Alabama	2,308	11,000	25,388	20.00	5,077,600
Arizona	100	11,250	1,125	17.00	191,250
California	183	20,000	3,660	25.00	915,000
Florida	400	18,000	7,200	13.50	972,000
Georgia	9,049	11,750	106,326	3.00	3,189,772
Maryland	186	7,500	1,395	39.00	544,050
North Carolina	1,300	16,000	20,800	17.25	3,588,000
New Jersey	250	11,000	2,750	20.00	550,000
New York	75	18,000	1,350	20.00	270,000
Ohio	275	19,080	5,247	32.00	1,679,040
Oklahoma	900	16,000	14,400	4.70	676,800
Pennsylvania	70	10,000	700	18.00	126,000
South Carolina	650	7,450	4,843	20.00	968,500
Tennessee	1,500	9,000	13,500	6.00	810,000
Texas	1,000	21,000	21,000	3.00	630,000
Virginia	400	9,000	3,600	20.00	720,000
U.S. Totals (of states reporting)	18,646	12,511	233,283	9.00	20,908,012

[1] Washington state produced seed (1,500 lb/acre) but no greens on 2,000 acres
[2] Acres that were planted once/year were counted once. Acres planted 2 times/year were counted as 2 acres, etc.
[3] Value ($) of greens to the producer in terms of receipts for the product.

The most important diseases of turnip greens for which control measures are directed include downy mildew (*Peronospora parasitica*), black rot (*Xanthomonas campestris*), seedling diseases (*Pellicularia filamentosa*, *Pythium* spp. and *Phytophthora* spp.) and various leaf spotting diseases caused by *Alternaria brassicicola*, *A. brassicae*, *Cercospora albomaculans*, *Cercosporella*

brassicae and *Colletotrichum higginsianum*. Seed producers in Washington state also experience trouble with white mold (*Sclerotinia sclerotiorum*). Downy mildew, black rot, Alternaria leaf spot and seedling diseases are serious problems in both the more humid and less humid regions of the country. Anthracnose, Cercospora leaf spot and Cercosporella leaf spot can occur throughout the country but they are major causes of loss in warm, humid regions. These diseases are the major cause of disease loss in the southeastern region of the country and, without the availability of effective fungicides for leaf spot control, this region could not economically produce turnip greens.

The fungicides used on turnip greens in U.S. production are listed in Table TG2 with the acres treated, use pattern, and pounds of ai used. Copper compounds were the most commonly used foliar fungicides, with about 10,700 acres treated and over 49,400 pounds of ai used. Copper was also used on 670 acres in combination with sulfur and 761 pounds of ai copper were applied with this combination. Copper is used principally for downy mildew and leaf spot control. It is frequently combined with sulfur to enhance leaf spot control. Benomyl was the second most commonly used foliar fungicide, with over 9,300 acres treated and over 4,600 pounds of ai applied. It is labeled for leaf spot control in the southeastern states only and was used in only three states: Alabama, Georgia and Tennessee. Sulfur was the third most commonly used foliar fungicide with 93 acres treated and about 800 pounds of ai applied. It was also applied to 670 acres in combination with copper and 4,758 pounds of ai sulfur were applied. It is used principally in combination with copper to enhance leaf spot control but is also used for powdery mildew control on limited acreage. Metalaxyl was used on 234 acres with 234 pounds of ai applied. It is used as a preplant soil treatment for seedling disease control and for early season downy mildew control. Captan was used on extensive turnip greens acreage (15,281 acres) as a seed treatment and almost 460 pounds of ai were used, while thiram was used on more than 1,700 acres as a seed treatment and over 50 pounds of ai were used. Both captan and thiram are used for seedling disease control.

Table TG2. Fungicide use in U.S. turnip greens production.

Fungicide	Treated acres	Use pattern[1]	Fungicide use lb ai
benomyl	9,333	F	4,648
captan	15,281	ST	458
copper	10,665	F	49,451
copper + sulfur	670	F	761 + 4,758
metalaxyl	234	PP	234
sulfur	93	F	800
thiram	1,715	ST	51
U.S. Total (of states reporting)			61,161

[1] F = Foliar, PP = preplant, ST = seed treatment

As with all of the leafy greens, the leaves must be blemish-free to be sold for fresh market use and must be relatively blemish-free to be sold for processing. Crops that are too heavily infected for sale are abandoned and not harvested. Even so, foliar fungicides are not used in North Carolina. Instead, farmers discard leaves, plants or whole fields that are infected. They deliberately overplant to make up this deficit, and they minimize costs by planting after field corn, thereby avoiding additional rent and utilizing the residual field corn fertilizer. All of their production is for fresh market, so they can afford hand labor to sort out infected leaves. The value of the crop for fresh market in the U.S. ranges between 17 and 39 cents a pound, and the value for the processing crop ranges between 3 and 6 cents a pound. Georgia, Oklahoma, Tennessee, and Texas produce turnip greens principally for the processing market. The other states produce the crop principally, or exclusively, for the fresh market.

Nonpesticide means of reducing loss in fields where disease is present include premature harvest when the crop is relatively disease-free, sorting and discarding disease-infected leaves, and raising the cutter-bar height to leave many of the more heavily infected lower leaves in the field. These practices can reduce yield by 5-25%, depending on disease severity and the practice employed.

Rotation, as practiced on almost 91% of the acreage, is utilized to assist in the control of seedling diseases, the various leaf spotting diseases and black rot. It is the major nonpesticide control practice used on turnip greens (Appendix, Table 16). Rotation reduces disease pressure by reducing inoculum levels, which permits other control strategies to be more effective. Growers normally plant turnip greens fields no more frequently than once in each two-year period. Seed producers plant fields no more frequently than once in a three-year period.

The impact of withdrawing individual fungicides from use is highly variable (Table TG3). The most critical fungicide is benomyl with a loss of more than 38 million pounds of greens from the loss of this fungicide. Two applications for leaf spot control are adequate when benomyl is used, while a minimum of three sprays is needed when alternate fungicides are used for control of these diseases. Copper would replace benomyl in the southeastern states if this use pattern were lost, but loss from phytotoxicity would increase. Since benomyl is labeled for the southeastern states only, its loss would not affect other regions of the country. The second most critical fungicide is copper, with a loss of over 36 million pounds of greens when used alone, and almost 1.2 million pounds where combined with sulfur. Since relatively few fungicides are labeled for use on turnip greens, there is no suitable fungicide replacement for copper. Preplant or at-planting metalaxyl treatments would provide early season control of downy mildew and the use of sulfur would provide some downy mildew and leaf spot suppression. However, neither of these fungicides would provide satisfactory season-long control under conditions of severe disease pressure. Benomyl would provide superior leaf spot control in states where it can be used legally. The third most commonly used foliar fungicide is sulfur, with a loss of 54,000 pounds of greens when used alone, and almost 1.2 million pounds where combined with copper. Sulfur is generally combined with copper to provide better leaf spot control and to permit the use of lower rates of copper. There is no suitable replacement for sulfur where sulfur is used alone. Where sulfur is combined with copper, no suitable replacement is available, except in Tennessee where benomyl is a suitable alternative fungicide. Metalaxyl is used on limited acreage as a preplant soil treatment for seedling disease and early season downy mildew control, and its loss would result in the loss of almost 153,000 pounds of greens. The relatively high cost of metalaxyl restricts its use to the fresh market

crop, since it is generally too expensive for the processing crop. No suitable replacement fungicide is available for metalaxyl. There would generally be no economic loss with the loss of either captan or thiram seed treatment, as long as one or the other retained its label. Growers in North Carolina would switch from thiram seed treatment to captan, with an expected loss of 2,340,000 pounds of greens with the loss of thiram seed treatment.

Table TG3. Impact of loss of individual fungicides on U.S. turnip greens production.

Fungicide lost	% Acres currently treated	% Yield impact on planted acres when alternatives are used	Yield impact lb leaf
benomyl	50.1	- 16.3	- 38,102,951
captan	82.0	0.0	0
copper	57.2	- 15.7	- 36,570,050
copper + sulfur	3.6	- 0.5	- 1,181,250
metalaxyl	1.3	< - 0.1	- 152,971
sulfur	0.5	< - 0.1	- 54,000
thiram	9.2	- 1.0	- 2,340,000

Georgia received a local label for the use of chlorothalonil for control of Cercospora and Cercosporella leaf spot diseases and for anthracnose control during 1993. The use of chlorothalonil will also provide very good downy mildew control. Since acreage and fungicide usage in Georgia is quite high, the labeling of chlorothalonil on turnip greens undoubtedly will have an influence on fungicide usage and crop loss to the national turnip greens crop in subsequent years.

Maneb was the principal fungicide used on turnip greens prior to its withdrawal. The percentage and number of acres treated prior to its withdrawal and the estimated current yield reduction from its loss are presented in Table TG4. In addition to the reported yield losses, many states indicated that acreage decreases have occurred and will continue to occur. The principal reasons given were increased production costs from use of more expensive fungicides, phytotoxicity of copper fungicides and generally poorer control of various leaf spotting diseases with presently labeled fungicides. Maneb use was rated as a critical need in most of the states of the southeast. The relative ineffectiveness of coppers for leaf spot control and the yield reduction associated with techniques used to sort healthy leaves from diseased leaves were cited as reasons for this loss. The local label for use of chlorothalonil in Georgia will permit an enhanced level of leaf spot control and should easily make up for the increase in total fungicide cost.

The data for turnip greens seed production are presented in the Appendix, Table 13 to 16. Copper and sulfur are not utilized in the seed production crop. Local use labels for two formulations of iprodione, for benomyl and for metalaxyl plus chlorothalonil have been secured and these fungicides are each used on 20% of the acreage. The principal use for iprodione and

benomyl is for white mold control and the principal use for metalaxyl plus chlorothalonil is for downy mildew and Alternaria leaf spot control. A combination seed treatment of thiram plus metalaxyl is used on 80% of the seed crop acreage for Rhizoctonia and Pythium root rot control. Seed producers plant turnip greens fields no more frequently than once in a three-year period for control of seedling diseases and suppression of white mold.

Table TG4. Impact of loss of maneb on U.S. turnip greens production.

State	Treated when labeled		% Yield impact on planted acres	Yield impact lb leaf
	% acres	acres		
Alabama	50	1,154	- 25	- 3,173,500
Arizona	50	50	- 10	- 56,250
California	100	183	- 10	- 366,000
Florida	60	240	- 40	- 1,728,000
Georgia	100	9,049	- 45	- 47,846,587
Maryland	30	56	- 10	- 42,000
North Carolina	50	650	- 10	- 1,040,000
New Jersey	90	225	- 10	- 247,500
Ohio	30	83	- 10	- 158,364
Oklahoma	25	225	- 15	- 540,000
Pennsylvania	30	21	- 10	- 21,000
South Carolina	90	585	- 25	- 1,089,563
Tennessee	80	1,200	- 30	- 3,240,000
Texas	95	950	- 10	- 1,995,000
Virginia	60	240	- 7	- 151,200
Washington	20[1]	400[1]	- 10[1]	[2]
U.S. Totals (of states reporting)	80.0	14,911	- 26.4	- 61,694,964

[1] Values not included in U.S. totals
[2] Loss of 10% of the seed produced (60,000 lb @ $0.50/lb)

On the seed crop acreage, the loss of metalaxyl seed treatment would result in a yield impact of 10%, with a loss of 240,000 pounds of seed. There is no suitable fungicide replacement for metalaxyl. The loss of the chlorothalonil plus metalaxyl foliar fungicide would result in a yield impact of 20%, with a loss of 120,000 pounds of seed. No suitable fungicide replacement is available for this combination. The loss of iprodione or benomyl would each result in a yield impact of 5%, with a loss of 30,000 pounds of seed for each fungicide. Iprodione would replace benomyl if lost and benomyl and chlorothalonil plus metalaxyl would replace iprodione. The loss of thiram seed treatment would result in no economic impact, since captan would serve as a suitable replacement.

The withdrawal of labels for all foliar fungicides for the seed crop would result in a loss of 25% (450,000 pounds seed). The withdrawal of all seed-treatment fungicide labels would result in a loss of 12% (288,000 pounds seed).

The loss of groups of fungicides for the edible crop is presented in Table TG5. The withdrawal of all foliar fungicide labels would result in a loss of over 46% of the crop (over 107 million pounds). The withdrawal of all seed-treatment fungicide labels would have a less profound, but still significant, impact (22.6 million pounds leaf), and the impact would vary considerably among the states. In general, in states where the crop is planted into cooler soils, the impact of the loss of seed-treatment chemicals would be more critical. The least significant impact would occur with the loss of preplant fungicides, with an impact of less than 0.1% (almost 153,000 pounds of greens).

Table TG5. Impact of loss of fungicide groups on U.S. turnip greens production.

Fungicide group lost	% Acres currently treated	% Yield impact on planted acres	Yield impact lb leaf
Foliar fungicides	67.8	- 46.1	- 107,495,225
Preplant fungicides	1.3	< - 0.1	- 152,971
Seed treatments	90.9	- 9.7	- 22,608,240

Most states indicated that acreage losses, as well as yield, have suffered since the maneb label was withdrawn, principally from the phytotoxicity problem with copper and the relatively poor control of leaf spotting diseases with currently labeled fungicides. If all foliar fungicides were lost, acreage decreases due to increased disease loss were anticipated in most of the states responding. North Carolina growers are unique in that they do not apply foliar fungicides to turnip greens. They manage to produce the crop economically by planting extra acres of the crop and harvesting those with low enough disease levels to market. Many other states report that the crop could not be economically produced without foliar fungicides and the crop would no longer be produced commercially, particularly for the processing industry.

Detailed information for individual states is included in the Appendix, Tables 13 to 16.

DISEASE CONTROL STRATEGIES AND THE IMPACT OF THEIR WITHDRAWAL ON LETTUCE

by

John K. Springer

Lettuce is grown in the United States on over 270,000 acres with an average yield of over 31,000 pounds of lettuce/acre (Table L1). Approximately 8.4 billion pounds of lettuce are produced in a normal year with a value of over $1 billion.

Table L1. Acres planted, yield and value of U.S. production for lettuce.

State	Planted acres[1]	Yield/acre (lb greens)	Yield/state (1,000 lb)	Values ($)[2] per lb	Value[2] ($1,000)
Arizona	55,500	25,250	1,401,375	0.14	196,193
California	195,000	34,000	6,630,000	0.12	795,600
Florida	11,000	18,600	204,600	0.23	47,058
New Jersey	2,522	14,000	35,308	0.13	4,590
New York	2,720	19,500	53,040	0.27	14,321
Ohio	1,230	14,280	17,564	0.25	4,391
Texas	750	10,000	7,500	0.10	750
Washington	1,460	27,300	39,858	0.15	5,979
U.S. Totals (of states reporting)	270,182	31,050	8,389,245	0.13	1,068,881

[1] Acres that were planted once/year were counted once. Acres planted 2 times/year were counted as 2 acres, etc.
[2] Value ($) to the producer in terms of receipts for the product.

The most important diseases of lettuce for which control measures are directed include downy mildew (*Bremia lactucae*), Septoria leaf spot (*Septoria lactucae*), Cercospora leaf spot (*Cercospora longissima)*, bottom rot (*Pellicularia filamentosa*), drop (*Sclerotinia sclerotiorum*), gray mold (*Botrytis cinerea*), bacterial spot (*Pseudomonas* sp.), and seedling diseases (*Pellicularia filamentosa*, *Pythium* spp., *Sclerotinia* spp. and *Botrytis* spp.).

The fungicides used on lettuce in U.S. production are listed in Table L2 with the acres treated, use pattern, and pounds of ai used. Iprodione was the most commonly used foliar fungicide, with over 133,600 acres treated and over 218,500 pounds of ai used. Maneb was the second most commonly used foliar fungicide, with over 116,200 acres treated and almost 500,000 pounds of ai applied. Vinclozolin was the third most commonly used foliar fungicide, with about 90,000 acres treated and almost 118,000 pounds of ai applied. Fosetyl-Al was the fourth most commonly used foliar fungicide, with almost 58,000 acres treated and over 330,000 pounds of ai applied. Metalaxyl was used on almost 50,000 acres with over 40,000 pounds of ai applied. Copper was the least commonly used foliar fungicide, with over 18,000 acres treated and almost 19,000 pounds of ai applied. Thiram was used as a seed treatment for over 17,000 planted acres and about 9 pounds of ai were used.

Table L2. Fungicide use in U.S. lettuce production.

Fungicide	Treated acres	Use pattern[1]	Fungicide use lb ai
copper	18,007	F	18,956
fosetyl-Al	57,751	F	330,614
iprodione	133,682	F	218,568
maneb	116,205	F	499,086
maneb + metalaxyl	300	F	960 + 168
metalaxyl	49,754	PP,F	40,171
thiram	17,637	ST	9
vinclozolin	90,040	F	117,670
U.S. Total (of states reporting)			1,229,204

[1] F = foliar, PP = preplant, ST = seed treatment

Rotation, as practiced on over 98% of the acreage, is utilized to assist in the control of seedling diseases, drop and bottom rot. It is the major nonpesticide control practice used on lettuce (Appendix, Table 20). Rotation reduces disease pressure by reducing inoculum levels, which permits other control strategies to be more effective. Most lettuce growers plant lettuce no more frequently than once in a two-year period. In New Jersey and New York, lettuce is traditionally grown for 2 to 3 years in the same field until drop becomes troublesome. The field is then rotated out of lettuce for a year or two to reduce the level of sclerotia in the soil before replanting to lettuce. In general, drop is a more troublesome disease in mineral soils and bottom rot is more troublesome in muck soils, although either disease can be troublesome on either soil type. Since a longer rotational scheme is needed to reduce drop inoculum levels than bottom rot inoculum levels, longer rotations may be practiced on mineral soils than on muck soils. The relatively high value of muck soils vs. mineral soils may also affect the rotational scheme employed. Other nonchemical practices employed to reduce disease levels are deep plowing to dilute the sclerotia levels in the soil and the use of resistant varieties for downy mildew control. Deep plowing is a practice that many growers employ even though they don't recognize this practice as being a nonchemical control measure.

The impact of withdrawing individual pesticides from use is somewhat less variable than with the other crops included in this report and the economic impact is often greater (Table L3). Maneb is the most critical fungicide in lettuce production, with over 540 million pounds of lettuce expected to be lost if this fungicide were not available. Maneb is used principally for downy mildew and leaf spot control and is the most economical to use. Alternative fungicides that would replace maneb include copper, fosetyl-Al and metalaxyl. Copper is generally too phytotoxic to use on lettuce, except under very specific weather conditions. Fosetyl-Al and metalaxyl would provide good control of downy mildew in regions where metalaxyl resistance isolates are absent but are more expensive to use and do not control the leaf spotting diseases as well as maneb. The second most critical fungicide is iprodione, with an expected loss of

more than 251 million pounds of lettuce if iprodione were unavailable. Iprodione is used for drop and bottom rot control, and vinclozolin would only replace some of the acreage treated with iprodione because vinclozolin is weak in the control of bottom rot. The third most critical fungicide is vinclozolin with an expected loss of more than 93 million pounds of lettuce. Iprodione would replace vinclozolin but would need to be applied more frequently due to its lower level of drop control. Withdrawal of the fosetyl-Al label would result in a loss of over 17 million pounds of lettuce. Maneb, metalaxyl or copper would likely replace fosetyl-Al if it were lost. The label for fosetyl-Al use on lettuce was received in late 1992. Thus, this fungicide could receive more usage as growers become accustomed to its benefits. The withdrawal of the metalaxyl soil treatment label would likely result in the loss of over 14 million pounds of lettuce, and no effective alternative fungicide is available. However, additional foliar fungicide applications may be used to reduce the loss. The loss of copper would not have an important economic impact on lettuce production, with a loss of about 70,000 pounds of lettuce from bacterial spot, and no suitable replacement is available. The loss of thiram seed treatment would result in a loss of 43.4 million pounds of lettuce, since this material is the only available seed treatment for lettuce. The combination of metalaxyl plus maneb is labeled for use in only one state, Texas. Nationwide, its loss would have minimal impact, with a loss of only 0.9 million pounds of lettuce. However, the lettuce industry in Texas would be severely impacted with a loss of 30% of the lettuce crop in that state.

Table L3. Impact of loss of individual fungicides on U.S. lettuce production.

Fungicide lost	% Acres currently treated	% Yield impact on planted acres when alternatives are used	Yield impact 1,000 lb leaf
copper	6.7	< - 0.01	- 70
fosetyl-Al	21.5	- 0.20	-17,238
iprodione	49.3	- 2.99	- 251,190
maneb	42.8	- 6.44	- 540,692
maneb + metalaxyl	0.3	- 0.01	- 900
metalaxyl	18.3	- 0.17	- 14,069
thiram	6.5	- 0.53	- 43,417
vinclozolin	33.2	- 1.11	- 93,669

The loss of groups of fungicides is presented in Table L4. If label clearance were removed for all foliar fungicides, a loss of almost 26% of the crop (over 2.1 billion pounds) would result. The loss of all seed-treatment fungicides would have a less profound, but still major, impact (over 43 million pounds) and the impact would vary considerably among the states. In general, in states where the crop is planted into cooler soils, the impact of the loss of seed-treatment chemicals would be felt more critically. The impact of the loss of preplant fungicides would be 0.2% with a loss of over 14 million pounds of lettuce.

Table L4. Impact of loss of fungicide groups on U.S. lettuce production.

Fungicide group lost	% Acres currently treated	% Yield impact on planted acres	Yield impact lb leaf lost (1,000 lb)
Foliar fungicides	92.7	- 25.6	- 2,150,369
Preplant fungicides	18.3	- 0.2	- 14,069
Seed treatments	6.5	- 0.5	- 43,417

Detailed information for individual states is included in the Appendix, Tables 17 to 20.

DISEASE CONTROL STRATEGIES AND THE IMPACT OF THEIR WITHDRAWAL ON SPINACH

by

John K. Springer

Spinach is grown in the United States on almost 40,000 acres with an average yield of over 12,600 pounds greens/acre (Table S1). This production yields over 504 million pounds of greens with a value of over $80 million.

Table S1. Acres planted, yield and value of U.S. production for spinach.

State[1]	Planted acres[2]	Yield/acre (lb greens)	Yield/state (1,000 lb)	Values ($)[3] (100 lb)	Value ($)[3] per state
Arkansas	1,000	5,900	5,900	30.00	1,770,000
Arizona	530	11,430	6,058	27.00	1,635,633
California	10,558	18,100	191,100	15.00	28,664,971
Delaware	800	7,800	6,240	20.00	1,248,000
Florida	300	5,000	1,500	24.50	367,500
Georgia	80	11,750	940	15.00	141,000
Maryland	2,700	8,100	21,870	58.00	12,684,600
North Carolina	1,000	8,000	8,000	17.00	1,360,000
New Jersey	2,551	7,800	19,898	14.00	2,785,692
New York	1,700	9,650	16,405	40.00	6,562,000
Ohio	65	11,000	715	55.00	393,250
Oklahoma	3,280	10,000	32,800	8.60	2,820,800
South Carolina	150	10,000	1,500	40.00	600,000
Tennessee	2,000	8,000	16,000	6.00	960,000
Texas	12,000	14,000	168,000	10.00	16,800,000
Virginia	1,200	6,000	7,200	26.00	1,872,000
U.S. Totals (of states reporting)	39,914	12,630	504,126	16.00	80,665,446

[1] Washington state produced seed (1,800 lb/acre) but no greens on 3,500 acres

[2] Acres that were planted once/year were counted once. Acres planted twice/year per year was counted twice, etc.

[3] Value ($) of greens to the producer in terms of receipts for the product.

Spinach is attacked by a number of leaf spotting diseases and several soil-borne fungi. Major diseases include white rust (*Albugo occidentalis*), blue mold (*Peronospora effusa*), Cercospora leaf spot (*Cercospora beticola*), anthracnose (*Colletotrichum spinacicola* and *C. spinaciae*), Cladosporium leaf spot (*Cladosporium macrocarpum*), seedling diseases and root rot (various fungi), and Fusarium wilt (*Fusarium oxysporum f. spinaciae*). Root and crown diseases are

troublesome in all regions of the country. These diseases are particularly troublesome when seeding into soil that is too wet and in fields in which the crop is overwintered. Low levels of these diseases result in poor stands and reduced yields, while heavy levels require reseeding of the field. Reseeding delays harvest and the crop may be unsalable because of the delayed harvest, or it may receive a reduced price. Leaf spot diseases, however, are more variable, being more of a problem in some states than others. In areas where foliar diseases are troublesome yearly, fungicides are applied to the foliage on nearly 100% of the acreage. In North Carolina, no foliar fungicides are used. Instead, farmers discard leaves, plants or whole fields that are infected. They deliberately overplant to make up this deficit, and minimize costs by planting after field corn, thereby avoiding additional rent and utilizing the residual field corn fertilizer. All of their production is for fresh market, so they can afford hand labor to sort out infected leaves. However, most states report that spinach could not be commercially produced without foliar fungicide sprays. The most prevalent diseases requiring foliar sprays are blue mold and white rust. The presence of either of these diseases can render an entire field unmarketable under favorable conditions for disease. Produce for the fresh market must be blemish-free. Produce that is not blemish-free may be downgraded to the processing market or may be unsalable. A crop from a field with a low level of one of the leaf spotting diseases may require sorting and discarding of infected leaves, may be downgraded in price for the processor, or may be completely abandoned. Crops that require additional man-hours for sorting also will experience a lower yield (5 to 10%) and may experience a reduction in quality. Many growers do not have the option of selling the crop to a processor and, thus, a crop with even low levels of disease may not be marketable.

The fungicides used on spinach in U.S. production are listed in Table S2 with the acres treated, use pattern, and pounds of ai used. Metalaxyl was the most widely used fungicide, with more than 34,500 treated acres and over 23,300 pounds of ai applied. The second most widely used fungicide was captan. It was used on over 31,000 acres, but because its use was as a seed treatment, only about 950 pounds of ai were used. Copper was the third most widely used fungicide on over 22,000 acres, but with the highest ai usage of more than 61,000 pounds. Other fungicides used were fosetyl-Al (5,424 acres treated and 19,237 pounds ai), thiram (9,750 acres and 310 pounds ai), and sulfur (856 acres treated and 5,046 pounds of ai when used in

Table S2. Fungicide use in U.S. spinach production.

Fungicide	Treated acres	Use pattern[1]	Fungicide use lb ai
captan	31,814	ST	955
copper	22,221	F	61,330
fosetyl-Al	5,424	F	19,237
metalaxyl	34,520	PP, F	23,362
sulfur	856	F	5,046
thiram	9,750	ST	310
U.S. Total (of states reporting)			110,240

[1] F = foliar, PP = preplant, ST = seed treatment

combination with copper). Maneb was the principal fungicide used on spinach prior to its loss; it had been used on over 90% of the spinach acreage when labeled (Table S5).

Rotation, used on over 90% of the U.S. acreage, is the major nonpesticide control practice used on spinach (Appendix, Table 24). Rotation frequently results in lower disease pressure and seed treatments work more effectively in this situation. In most states, growers plant spinach no more frequently than once in a two-year period. Seed producers plant spinach once in a four-year period. Another important nonpesticide control practice used in Texas and New York is the use of resistant varieties (25.8% of U.S. acreage) for the management of white rust and blue mold. Unfortunately, those varieties that are resistant are not suitable for many production areas of the country. Where they are suitable, they are often not the dominant variety being grown. However, they could be used in some regions if fungicide usage became more restrictive. Another practice utilized in Texas is furrow irrigation (18% of U.S. acreage) to manage white rust and blue mold.

The impact of withdrawing individual pesticides from use is variable (Table S3). By far, the withdrawal of metalaxyl would result in the gravest consequences. No fungicide can replace the preplant use of metalaxyl; foliar application of fosetyl-Al and copper are generally expected to result in less effective control. Across the U.S., the impact of metalaxyl withdrawal is expected to be about 20% on spinach yield, or a reduction of almost 100 million pounds of greens when used alone. Additionally, a loss of almost 1% (over 4 million pounds) of greens would occur from the loss of the combination product containing metalaxyl and copper. The loss of copper is second in importance on spinach, with an impact of 8.5% on yield or a reduction of more than 42 million pounds of greens when used alone as a foliar spray. Additional losses of 0.8% (over 4 million pounds) and 0.07% (over 0.3 million pounds) of greens would occur from the loss of the combinations of copper plus metalaxyl and copper plus sulfur, respectively. Fosetyl-Al is expected to replace copper in nearly half the situations where it is withdrawn, while no replacement is expected for the other half. The third most important fungicide on spinach in terms of yield impact if it were to be withdrawn is fosetyl-Al. If it were lost, the impact is expected to be more than 6% on yield or over 31 million pounds of spinach lost. The remaining fungicides, captan, sulfur, and thiram, are of minor consequence if individually withdrawn. It should be pointed out that captan and thiram are viewed as fungicides whose withdrawal

Table S3. Impact of loss of individual fungicides on U.S. spinach production.

Fungicide lost	% Acres currently treated	% Yield impact on planted acres when alternatives are used	Yield impact lb leaf
captan	79.7	0.00	0
copper	38.7	- 8.50	- 42,872,017
copper + metalaxyl	10.3	- 0.80	- 4,048,234
copper + sulfur	2.1	- 0.07	- 344,000
fosetyl-Al	13.6	- 6.20	- 31,331,143
metalaxyl	76.2	- 19.80	- 99,737,833
thiram	24.4	- 0.20	- 900,000

individually would have a minor impact only, because they replace one another. If there were no seed-treatment fungicides available, a large impact would be expected (Table S4).

This points out the importance of knowing the impact of pesticide groups (Table S4). For instance, if all foliar fungicides were withdrawn, the expected impact is 22% on yield or a reduction of over 112 million pounds of spinach. These values are probably underestimates of the actual loss, since many states indicated that spinach could not be produced commercially without foliar fungicides. If the preplant metalaxyl treatment were removed, a loss of almost 20% (almost 100 million pounds) of greens would occur. If all seed-treatment fungicides were withdrawn, we would expect a 5% impact on yield or a reduction of over 25 million pounds of spinach. These numbers point out the importance of these fungicide groups to United States spinach production.

Table S4. Impact of loss of fungicide groups on U.S. spinach production.

Fungicide group lost	% Acres currently treated	% Yield impact on planted acres	Yield impact lb leaf
Foliar fungicides	61.1	- 22.3	- 112,561,315
Preplant fungicides	76.2	- 19.8	- 99,737,833
Seed treatments	99.8	- 5.0	- 25,163,098

The loss of maneb-containing fungicides has had a profound effect on spinach production, with a yield impact of nearly 17% (over 85 million pounds of greens)(Table S5). Some of the fungicides that have replaced maneb (fosetyl-Al and metalaxyl) are too expensive to use in many areas of production, and fosetyl-Al is labeled for blue mold control only. Metalaxyl has a more restrictive preharvest interval (21 days) than did maneb, which restricts its use when late infections occur. The long preharvest interval of metalaxyl also restricts its use when the crop is growing rapidly, since harvest can occur within 25 days of seeding. Other fungicides that have replaced maneb (copper-containing fungicides and sulfur) are often too phytotoxic to use and are much less effective against the diseases requiring control. Some states have reported a reduction in acreage because of the increased cost of production and the grower's inability to secure sufficient returns to justify these increased costs.

Of even more concern over the loss of maneb is the inability to manage fungicide resistance and the relative ineffectiveness of presently labeled fungicides against the various leaf spotting diseases. The two most effective fungicides against blue mold are fosetyl-Al and metalaxyl. Both of these materials are highly specific in their spectrum of activity, whereas maneb was general. These fungicides have been available for grower use for a short time only, and the potential for the development of fungicide-resistant strains is quite high. Thus, the longevity of these materials may be greatly reduced when used without a companion protectant fungicide. Metalaxyl is currently formulated with basic copper sulfate to delay resistance development, but most respondents indicated that copper usage frequently is too phytotoxic. Thus, growers in most production areas would more readily adopt a combination of metalaxyl with maneb than metalaxyl with copper. In some areas, however, maneb has a perception problem, which would preclude its usage.

Table S5. Impact of loss of maneb on U.S. spinach production.

State	Treated when labeled		% Yield impact on planted acres	Yield impact lb leaf
	% acres	acres		
Alabama	20	200	- 10	- 118,000
Arizona	70	371	- 10	- 424,053
California	100	10,558	- 25	- 47,774,950
Delaware	95	760	- 10	- 592,800
Florida	10	30	- 2	- 3,000
Georgia	100	80	- 30	- 282,000
Maryland	40	1,080	- 15	- 1,312,200
North Carolina	80	800	- 10	- 640,000
New Jersey	95	2,423	- 10	- 1,889,940
New York	100	1,700	-20	- 3,281,000
Ohio	80	52	- 10	- 57,200
Oklahoma	90	2,952	- 25	- 7,380,000
South Carolina	50	75	- 10	- 75,000
Tennessee	90	1,800	- 25	- 3,600,000
Texas	100	12,000	- 10	- 16,800,000
Virginia	95	1,140	- 20	- 1,368,000
Washington	40[1]	1,400[1]	- 20[1]	[2]
U.S. Totals (of states reporting)	90.25	36,021	- 16.98	- 85,598,143

[1] Values not included in U.S. totals
[2] Loss of 10% of the seed produced (60,000 lb @ $0.50/lb)

The data for spinach seed production are presented in the Appendix, Tables 21 to 24. Spinach seed production fields in Washington state are handled differently from fields where the crop is grown for human consumption. The combination products metalaxyl plus copper and metalaxyl plus chlorothalonil are each used on 700 acres (1,400 total acres or 40% of the acreage) as a foliar spray for blue mold and Alternaria leaf spot control. The loss of metalaxyl would result in a yield reduction of 20% on the acreage treated with metalaxyl plus chlorothalonil, with a loss of 252,000 pounds of seed and a yield reduction of 15% on the acreage treated with metalaxyl plus copper, with a loss of 189,000 pounds of seed. No fungicide is a suitable replacement for either combination. If the maneb label were reinstated for seed production purposes, 40% of the acres treated with the combination products would be treated with maneb. This would increase yields by 20% on the 40% of the acres treated with the fungicide combinations. A combination seed treatment of captan, benomyl and metalaxyl is used on 100% of the seed used for the seed crop. All components of the seed treatment are used for seedling disease and root rot control, while the benomyl component also assists in Fusarium wilt control. The loss of

captan for seed-treatment purposes would have no effect on yield, since it would be replaced with thiram. There are no suitable replacements for benomyl and metalaxyl seed treatment, and yield would be reduced by 5% (loss of 315,000 pounds seed) and 7% (loss of 441,000 pounds seed), respectively.

The loss of all foliar fungicides on the seed crop would have a 40% yield impact, with the loss of over 1 million pounds of seed, while the loss of all seed-treatment materials would reduce stands and have a 12% yield impact, with the loss of 756,000 pounds of seed from seedling diseases and Fusarium wilt. Seed producers do not use a preplant metalaxyl soil treatment, but substitute with a five-year rotational scheme where the crop is planted only once every 5 years on the same land.

Detailed information for individual states is included in the Appendix, Tables 21 to 24. Information on spinach grown for seed in Washington state is included in the Appendix, Tables 21 to 24.

POTENTIAL ECONOMIC EFFECTS OF BANNING FUNGICIDES USED ON LEAFY GREEN VEGETABLES

by

Craig Osteen

This chapter presents estimates of the economic impacts of losing the use of individual fungicides and major groups of fungicides, based on the use of alternatives and associated yield losses presented in this assessment (Appendix). It also discusses the implications of the results for the regulatory process. The use of pesticides can be "lost" due to such policy decisions as cancellation under EPA special review, voluntary cancellation by the registrant, suspension and cancellation during reregistration, or to biological factors, such as reduced effectiveness caused by pathogen resistance.

Methods

Economic effects estimated for lettuce and spinach include impacts on producers and consumers of the crops, the net effect, and price changes using demand and supply elasticities. The economic effects for collards, kale, mustard greens, and turnip greens were computed by partial budgetting, holding prices constant. The reason is that relatively little information about such market parameters as price, output, and elasticities of demand and supply is available for collards, kale, mustard greens, and turnip greens, whereas demand and supply elasticities have been estimated for head lettuce and spinach (Table ECON1).

Table ECON1. Acreage, production, prices, and elasticities.

Crop	Acreage (1,000's)	Production (million lb)	Price ($/lb)	Demand elasticity	Supply Elasticity	
					short run	long run
Collards	21.4	259.1	0.160	NA	NA	NA
Kale	7.2	95.0	0.147	NA	NA	NA
Lettuce	270.1	8,389.2	0.127	- 0.15	0.23	1.7
Mustard greens	9.8	115.6	0.122	NA	NA	NA
Spinach	39.9	504.1	0.160	- 0.70	0.20	4.7
Turnip greens	18.6	233.3	0.090	NA	NA	NA
NA = not available						

The economic effects on collards, kale, mustard greens, and turnip greens were estimated as the value of yield loss plus change in production cost resulting from the regulatory action:

$$TE = qP - cT$$

where:

$$TE = \text{total economic effect}$$
$$q = \text{change in output}$$
$$P = \text{output price}$$
$$c = \text{change in total production cost per treated acre}$$
$$T = \text{treated acreage}$$

The values for crop prices, pesticide prices, treated acreage, and yield losses were obtained from the leafy green assessment team. This simple calculation provides an estimate of the total economic loss for these crops. It does not show the distributional effects on consumers and producers, unless output prices would not change significantly in response to a regulatory action. In such case, the loss would be borne entirely by growers using the pesticide.

A different approach was used to compute economic effects for lettuce and spinach. Price effects generate distributional effects on producers and consumers. To compute price and output changes, demand and supply functions are assumed to behave as constant elasticity or log-linear models (Gardner, 1983, and Lichtenberg and Zilberman, 1986):

$$P_d = aQ^x$$

$$P_s = bQ^y$$

where:

$$P_d = \text{farm-level price offered per unit of output}$$
$$P_s = \text{price received} = \text{marginal cost per unit of output}$$
$$Q = \text{quantity demanded or supplied}$$
$$x = \text{inverse of demand elasticity } (x<0)$$
$$y = \text{inverse of supply elasticity } (y>0)$$

At equilibrium:

$$P_e = P_d = P_s$$

$$Q_e = (b/a)^{1/(x-y)}$$

$$P_e = bQ_e^y = aQ_e^x$$

where:

$$P_e = \text{equilibrium farm-level price}$$
$$Q_e = \text{equilibrium output}$$

Q_e and P_e were obtained from assessment and USDA National Agricultural Statistics Service data; x and y were obtained from other sources. Values were estimated for a and b from the system of equations, assuming the values obtained for Q_e, P_e, x, and y.

Pesticide bans can modify the supply function, P_s, by changing output for a given level of cost or changing cost per unit of output for a given level of output. In this analysis, the supply function for lettuce or spinach is modified as follows:

$$P_s = b(1+d)(1+f)^{-y} Q^y,$$

where:

d = change in cost per unit of output as a proportion of current price = $(cT/Q_e)/P_e$ [1]
f = proportional change in yield per planted acre $(-1 \leq f \leq 1)$ [2]

Estimates for d and f were obtained from assessment information.
The new equilibrium output, Q_n, becomes:

$$Q_n = (1+d)^{1/(x-y)} (1+f)^{-y/(x-y)} Q_e,$$

and new equilibrium price, P_n, becomes:

$$P_n = (1+d)^{x/(x-y)} (1+f)^{-xy/(x-y)} P_e$$

Total impact is the sum of impact on consumers and producers:

$$TE = CE + PE$$

where:

CE = consumer effect
PE = producer effect

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[1] The proportional per-unit cost change, d, should actually have P_s as the denominator rather than P_e, making d a variable instead of a constant. Including d as a constant is an approximation to avoid a difficult calculation of solving P_s as a function of P_s, while allowing cost changes to modify equilibrium price and output. The error in d introduced by the approximation is small for small changes in P_s. The error in d becomes smaller as supply elasticity increases (y becomes smaller). For an infinite supply elasticity (y = 0), the supply function becomes a horizontal line, $P_s = b(1+d)$, that is shifted by the constant, d, and the error introduced by the approximation disappears.

[2] Production change was included by solving for Q as a function of P_s and multiplying the right side of the equation by 1+f (ignoring d in the example):

$$Q = (1+f)(P_s/b)^{1/y}$$

Solving for P_s, the equation becomes:

$$P_s = b[Q/(1+f)]^y = b(1+f)^{-y} Q^y$$

The effect on consumers (change in consumer surplus), actually on purchasers of farm-level output, is approximated by:

$$CE = (P_n - P_e)(Q_n + Q_e)/2$$

The producer effect (change in producer surplus) is approximated by:[3]

$$PE = A + B$$

where:

$$A = \text{impact on current acreage} = P_nQ_e(1+f) - P_eQ_e - cT$$

$$B = \text{impact due to change in acreage and other input use}$$

$$= [P_n - P_e(1+d)][Q_n - Q_e(1+f)]/2$$

When price change was computed to be less than 1%, it was assumed to be negligible, and the impact was computed in the same way as for collards, kale, mustard greens, and turnip greens:

$$TE = qP - cT$$

The per-acre impact (gain or loss) on acreage treated with a pesticide or group, due to yield loss, cost change, and price increase, is:

$$I_t = (P_n - P_e)Y - P_nz - c$$

where:

I_t = per-acre financial impact on currently treated acreage
Y = yield per acre before ban
z = yield loss per treated acre caused by ban

The per-acre impact on acreage not treated with the pesticide or group, due to higher price and no change in yield or cost, is:

$$I_u = (P_n - P_e)Y$$

where:

I_u = Per-acre financial impact on acreage not treated

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[3] The linear approximation of producer impact was used because the integration of the supply function underestimates cost change when d is included as a constant rather than a variable (See footnote 1). However, as the supply elasticity approaches infinity and the supply function becomes a horizontal line, $P_s = b(1+d)$, the producer impact that includes cost as the integration of the supply function approaches PE.

Impacts on current crop acreage in each state were computed from the estimated per-acre impacts and estimates of treated and untreated acreage:

$$S = I_t \times T + I_u \times U$$

where:

S = Financial impact on acreage currently grown in a state
U = Acreage currently not treated

The estimates of S do not show the overall impact in each state, because changes in acreage and other input use are not estimated for each state. However, these estimates help to indicate where production will be discouraged and where it will be encouraged.

Supply elasticities account for supply adjustments in response to price changes. Supply adjustments can occur through domestic producers changing acreage or other input use, or through changes in imports. Since imports of lettuce and spinach account for less than 1% of U.S. supply of those commodities, supply adjustments are assumed to be primarily the result of changes in the use of domestic crop acreage and other inputs. In the case of large price increases, imports could increase to bid away market share and moderate price increases and consumer losses. Long-run supply elasticities allow for more adjustment than the short-run elasticities. Hence, supply elasticity for the long run is larger (y is smaller) than for the short run (Table ECON1).

The short-run results can best be viewed as what would occur if the use of a pesticide were terminated abruptly before a growing season began. The long-run results show what would occur after several years and growers have adjusted acreage and other input use in response to yield, cost, and short-term price changes. The long-run results also show what would occur if the use of a pesticide were cancelled while allowing existing stocks to be used or if use were phased-out, which gives growers time to adjust without experiencing an abrupt change in cost and yields. Since most regulatory decisions allow the use of existing stocks, the long-run results for lettuce and spinach are a better indicator of price and welfare effects in most cases than the short-run results. So, the long-run impacts will be emphasized in the discussion of lettuce and spinach.

The economic effects should be viewed as rough estimates, because there are many sources of uncertainty. The estimates of pesticide use, yield loss, and choices of alternative practices are based on expert estimates. Fungicide use estimates for lettuce and spinach in this assessment vary from 1992 National Agricultural Statistics Service (NASS) survey estimates for materials in some states (USDA, 1993). (NASS does not have estimates for collards, kale, mustard greens, and turnip greens.) This is to be expected since fungicide use varies from year to year and the expert estimates in this assessment were made before the NASS report was released in June 1993. However, NASS inadvertently did not summarize and, thus, underestimated fungicide use on California head lettuce. State of California data show lettuce fungicide use to be comparable to that estimated in this report.

Also, the NASS report shows fewer spinach acres treated with metalaxyl than this report shows. Part of the difference could be due to the similarity of at-planting treatments of

metalaxyl to farmer-applied seed treatments, which NASS does not summarize. State of California pesticide data show a level of metalaxyl use on spinach similar to that estimated by NAPIAP. In some other states, NASS did not publish estimates for some lettuce or spinach fungicides because of insufficient reports. This assessment shows a high percentage of acres treated with some fungicides in some of these states, but this does not mean that the NAPIAP estimates are inaccurate. Because of the small number of operations reporting to NASS in these states, the individual materials could be used on a high percentage of acreage even though NASS does not have enough reports to publish estimates.

The cost and yield changes may be overestimated by an unknown amount, because not all adjustments available to producers were necessarily considered. Similarly, many of the economic variables are not precise. Pesticide prices are based on information from distributors and registrants, which may not be what farmers actually pay. As a result, cost change estimates could vary from actual changes by several dollars per acre. Also, statistical information on the prices, acreage, and production of collards, kale, mustard greens, and turnip greens were not available from the National Agricultural Statistics Service. Only one year of information was available for spinach. So, the experts estimated values for these variables as well. Finally, the economic model and estimates of elasticities should not be viewed as precise. There is no statistical measure of accuracy or precision for the economic estimates. However, the estimates should be reasonably accurate, given the available information.

Results

The presentation of economic effects follows. Collards, kale, mustard greens, and turnip greens are treated as a group, because the effects were estimated with partial budgetting methods. Lettuce and spinach are presented separately, because elasticities were used to compute price changes and welfare effects.

Collards, Kale, Mustard Greens, and Turnip Greens

These crops are produced for both fresh and processing markets. Since the prices for fresh-market production are higher than those for processing, there is wide variation in prices received among states, depending upon the proportions of production in each state for each market. Georgia is the largest producing state for all four crops. It accounts for 30-40% of the acreage and production of collards, kale, and mustard greens, and 45-50% for turnip greens. However, much of Georgia's production is for processing, so that it only accounts for 10-15% of the value of production. Oklahoma, Tennessee, and Texas also produce largely for processing markets and receive low prices. Many small-acreage states produce primarily for fresh market and receive much higher prices.

Seed treatments are used on 90% or more of the acreage of each crop (Tables ECON2, ECON3, ECON4, and ECON5). Captan is the most widely used seed treatment, exceeding 70% of the acreage of each crop. Thiram is used in North Carolina, New York, Ohio, Tennessee, Texas, and Virginia and on 10-20% of the U.S. acreage of each crop. Benomyl is used in combination with thiram as a seed treatment in Ohio on collards and kale. The aggregate impact of banning any one of these chemicals is very small (2% of U.S. crop value or less), because captan and thiram are good alternatives to each other in many circumstances. The exception is in North Carolina where yield losses and financial losses, as a portion of that state's crop value, would exceed 10% if thiram were banned (Tables ECON6, ECON7, ECON8, and ECON9).

However, if all seed treatments were banned, relatively large yield losses to seedling diseases, averaging 8-10%, would occur. Economic losses would be on the order of 10% of the U.S. value of these crops if all seed treatments were banned. The loss of all seed treatments would discourage production in the south and east because of large proportional yield and financial losses, while Arizona and California would have relatively low yield and financial losses. Texas and Tennessee, which produce primarily for the processing market, also incur low yield and financial losses.

Table ECON2. Collards: impact of bans of selected fungicides.

Fungicide	Acres Treated (%)	Impact per Treated Acre				Total Impact	
		cost change ($/A)	yield change (%/A)	monetary ($/A)	% of value/A	monetary ($1,000)	% of crop value
Foliar Treatments							
copper compounds	48	- 9	- 33	- 226	22	- 2,338	6
fosetyl-Al	5	- 23	- 19	- 195	13	- 229	< 1
sulfur	4	- 7	- 16	- 389	11	- 338	< 1
all foliar fungicides	55	- 34	- 57	- 390	36	- 4,557	11
Seed Treatments							
captan	81	< 1	0	< 1	< 1	< 1	< 1
thiram	17	< 1	- 6	- 202	7	- 740	2
all seed treatments	98	< 1	- 10	- 200	10	- 4,224	10

Table ECON3. Kale: impacts of bans of selected fungicides.

Fungicide	Acres Treated (%)	Impact per Treated Acre				Total Impact	
		cost change ($/A)	yield change (%/A)	monetary ($/A)	% of value/A	monetary ($1,000)	% of crop value
Foliar Treatments							
copper compounds	6	6	- 6	- 253	7	- 103	< 1
fosetyl-Al	5	- 47	- 4	- 177	4	- 64	< 1
maneb	55	- 19	- 20	- 191	15	- 749	5
sulfur	3	2	- 10	- 592	10	- 106	< 1
all foliar fungicides	65	- 33	- 51	- 467	28	- 2,175	16
Seed Treatments							
captan	87	< 1	0	< 1	< 1	< 1	< 1
thiram	13	< 1	- 4	- 115	5	- 105	< 1
all seed treatments	99	< 1	- 8	- 152	8	- 1,084	8

Table ECON4. Mustard Greens: impacts of bans of selected fungicides.

Fungicide	Acres Treated (%)	Impact per Treated Acre				Total Impact	
		cost change ($/A)	yield change (%/A)	monetary ($/A)	% of value/A	monetary ($1,000)	% of crop value
Foliar Treatments							
copper compounds	46	- 22	- 23	- 70	10	- 319	2
fosetyl-Al	3	- 30	- 8	- 269	8	- 79	< 1
sulfur	5	< 1	- 3	- 47	1	- 21	< 1
all foliar fungicides	49	- 31	- 32	- 138	17	- 657	5
Seed Treatments							
captan	73	< 1	0	< 1	< 1	< 1	< 1
thiram	16	< 1	- 8	- 163	8	- 256	2
all seed treatments	89	< 1	- 10	- 166	- 11	- 1,438	10

Table ECON5. Turnip Greens: impacts of bans of selected fungicides.

Fungicide	Acres Treated (%)	Impact per Treated Acre				Total Impact	
		cost change ($/A)	yield change (%/A)	monetary ($/A)	% of value/A	monetary ($1,000)	% of crop value
Foliar Treatments							
benomyl	50	4	- 35	- 210	38	- 1,962	9
copper compounds	61	- 27	- 26	- 124	20	- 1,402	7
sulfur	4	- 24	- 10	- 339	12	- 259	1
all foliar fungicides	68	- 44	- 68	- 334	44	- 4,215	20
Seed Treatments							
captan	82	< 1	0	< 1	< 1	< 1	< 1
thiram	9	< 1	- 8	- 236	11	- 404	2
all seed treatments	91	< 1	- 10	- 139	- 12	- 2,360	11
Preplant Treatments							
metalaxyl	1	- 74	- 6	- 46	2	- 11	< 1

Table ECON6. Collards: economic impacts on current planted acreage, by state.

State	Foliar Materials				Seed Treatments		
	copper	fosetyl-Al	sulfur	all	captan	thiram	all
	--------------------------------Percent of Crop Value--------------------------------						
Alabama	- 15	*	*	- 15	*	*	- 20
Arizona	*	*	*	*	*	*	- 7
California	*	*	- 3	- 5	*	*	*
Florida	- 1	*	- 2	- 6	*	*	- 7
Georgia	- 34	- 2	*	- 66	*	*	- 10
Maryland	*	- 1	*	- 3	*	*	- 12
North Carolina	*	*	*	*	*	- 11	- 11
New Jersey	*	*	*	- 1	*	*	- 10
New York	- 13	*	*	- 13	*	*	- 15
Ohio	- 5	- 8	- 5	- 24	*	*	- 10
Oklahoma	*	*	*	*	*	*	- 10
Pennsylvania	- 1	*	*	- 2	*	*	- 10
South Carolina	- 4	*	*	- 13	*	*	- 18
Tennessee	*	*	*	*	*	*	- 1
Texas	- 49	*	- 19	- 49	*	*	- 1
Virginia	*	*	*	- 1	*	*	- 10
* = less than 1%							

Table ECON7. Kale: economic impacts on current planted acreage, by state.

State	Foliar Materials					Seed Treatments		
	copper	fosetyl-Al	maneb	sulfur	all	captan	thiram	all
	Percent of Crop Value							
Arizona	*	*	- 1	*	- 1	*	*	- 7
California	*	*	- 8	*	- 13	*	*	*
Florida	*	*	*	*	*	*	*	- 7
Georgia	*	*	- 19	*	- 78	*	*	- 10
Maryland	*	*	- 5	*	- 6	*	*	- 13
North Carolina	*	*	*	*	*	*	- 11	- 12
New Jersey	*	*	- 2	*	- 2	*	*	- 10
New York	- 6	*	*	*	- 6	*	*	- 25
Ohio	- 9	- 8	*	- 9	- 19	*	*	- 10
Oklahoma	*	*	*	*	*	*	*	- 10
Pennsylvania	*	*	*	*	*	*	*	- 10
South Carolina	*	*	- 5	*	- 6	*	*	- 25
Tennessee	*	*	- 9	*	- 9	*	*	- 1
Texas	*	*	- 6	*	- 23	*	*	- 1
Virginia	*	*	- 2	*	- 12	*	*	- 10

* = less than 1%

Table ECON8. Mustard Greens: economic impacts on current planted acreage, by state.

State	Foliar Materials				Seed Treatments		
	copper	fosetyl-Al	sulfur	all	captan	thiram	all
	---------------Percent of Crop Value---------------						
Alabama	- 2	*	*	- 2	*	*	- 20
Arizona	*	*	*	*	*	*	- 7
California	*	- 3	*	- 3	*	*	*
Florida	- 1	*	- 1	- 1	*	*	- 7
Georgia	- 13	*	*	- 23	*	*	- 10
Maryland	*	- 1	*	- 3	*	*	- 12
North Carolina	*	*	*	*	*	- 11	- 11
New Jersey	*	*	*	- 1	*	*	- 10
New York	- 13	*	*	- 13	*	*	- 25
Ohio	*	- 2	*	- 14	*	*	- 10
Oklahoma	*	*	- 1	- 1	*	*	- 10
Pennsylvania	*	*	*	*	*	*	- 10
South Carolina	- 4	*	*	- 7	*	*	- 20
Tennessee	*	*	*	*	*	*	*
Texas	- 45	*	*	- 45	*	*	- 1
Virginia	- 1	*	*	- 1	*	*	- 5

* = less than 1%

Table ECON9. Turnip Greens: economic impacts on current planted acreage, by state.

State	Foliar Materials				Seed Treatments			Preplant
	benomyl	copper	sulfur	all	captan	thiram	all	metalaxyl
	--Percent of Crop Value--							
Alabama	- 18	- 1	*	- 22	*	*	- 20	*
Arizona	*	*	*	*	*	*	- 7	*
California	*	*	*	*	*	*	*	*
Florida	*	*	- 1	- 2	*	*	- 7	*
Georgia	- 33	- 17	*	- 70	*	*	- 10	*
Maryland	*	- 1	*	- 2	*	*	- 12	*
North Carolina	*	*	*	*	*	- 11	- 11	*
New Jersey	*	*	*	*	*	*	- 7	*
New York	*	- 13	*	- 13	*	*	- 15	*
Ohio	*	- 14	- 14	- 14	*	*	- 5	*
Oklahoma	*	- 2	- 2	- 2	*	*	- 12	*
Pennsylvania	*	*	*	*	*	*	- 12	- 3
South Carolina	*	- 29	*	- 32	*	*	- 18	*
Tennessee	*	*	*	- 1	*	*	*	*
Texas	*	- 35	*	- 35	*	*	- 1	*
Virginia	*	- 1	*	- 2	*	*	- 5	*

* = less than 1%

Foliar fungicides are used on less acreage than seed treatments, between 50 and 70% of the crop acreage. However, use of foliars was not reported on any of the four crops in North Carolina, kale in Oklahoma, kale and mustard greens in Pennsylvania, and turnip greens in California and Arizona.

Generally, one active ingredient accounts for most of the use of foliar fungicides on each of these crops and would have the largest impact if banned. Copper compounds are used on 48% of collard acreage and 46% of mustard green acreage. On kale, maneb is used on 55% of the acreage. However, on turnip greens, benomyl is used on 50% of the acreage and copper compounds on 61%.

On collards and mustard greens, the loss of copper fungicides would cause the largest impact: 6% of the U.S. value of collards and 2% of mustard greens. The loss of maneb would have the largest impact on kale, about 5% of the U.S. value. On turnip greens, the loss of benomyl would cause financial losses of 9% of U.S. turnip green value, while the loss of copper compounds would cause losses of 7%. The loss of all foliar fungicides would cause financial

losses of 11% of U.S. crop value for collards, 16% for kale, 5% for mustard greens, and 20% for turnip greens. The loss of fosetyl-Al, sulfur, or metalaxyl (a preplant compound used on turnip greens) would have a minimal aggregate impact.

Although some of the foliar fungicides will serve as alternatives to each other on various diseases, yield losses will often occur when changing from one to another. In many cases, there are no effective alternatives to a specific pesticide for a disease problem. This is a much different pattern than occurs with seed treatments, where the alternatives perform comparably in most states. Individual foliar materials often fill unique disease control niches. For example, the impact of banning all foliar fungicides would be about twice the sum of impacts from banning each individually, assuming the others are available. (If each material controls different pests so that none are alternatives to each other, the impact of banning the group would equal the sum of the individual bans.) For seed treatments, the factor is 5 to 10 times.

The impacts from losing individual or all foliar materials generally would be larger in the southern and eastern states (Tables ECON6, ECON7, ECON8, and ECON9) than in the western states. If no foliar fungicides could be used, the largest proportional financial and production losses for all four crops would occur in Georgia and Texas, which produce largely for processing markets. The loss of copper would cause large impacts in Texas collard, mustard green, and turnip green production; in Georgia collard and mustard green production; in New York production of all four crops; in Ohio kale and mustard green production; and in South Carolina turnip green production. The loss of maneb would cause the largest losses in Georgia kale production. The loss of benomyl would cause the largest losses in Georgia and Alabama turnip green production. However, the loss of maneb or all foliar fungicides would cause large losses for California kale production.

Lettuce

Three states account for 96% of U.S. lettuce acreage and 98% of U.S. production: Arizona, California, and Florida. California is by far the largest, accounting for 72% of acreage and 79% of production. Arizona is the second largest with 20% of acreage and 17% of production, and Florida accounts for 4% of acreage and 2% of production. Several other states produce for seasonal and local markets.

In contrast to collards, kale, mustard greens, and turnip greens, foliar applications on lettuce are more common than seed treatments: 93% of the acres are treated with foliar materials and 7% with seed treatments (Table ECON10). The primary foliar treatments are copper compounds (7% of acres treated), fosetyl-Al (21%), iprodione (50%), maneb (41%), and vinclozolin (33%). The primary seed treatment is thiram used on 7% of the acres. In addition, metalaxyl, a preplant treatment, is applied to 19% of lettuce acres.

Although iprodione is more widely used, the loss of maneb would cause the largest economic losses to producers and consumers of lettuce -- $90 million or 8% of U.S. lettuce value. The loss of iprodione would cause economic losses of $33 million (3% of U.S. lettuce value), while the loss of vinclozolin would cause losses of $13 million (1% of U.S. lettuce value). Losing the seed treatment, thiram, would cause financial losses of $10 million (less than 1% of U.S. lettuce value). The impacts of losing copper compounds, fosetyl-Al, or metalaxyl for use on lettuce would be negligible. In the short run, if use were terminated abruptly before the start of a

Table ECON10. Lettuce: economic impacts of bans of selected fungicides.

Fungicide	Acres treated (%)	Impact per Acre				Price Change (%)		Output Change (%)		Total Impact (long-run) ($1,000)		
		cost change ($/A)	yield change (%/A)	total monetary ($/A)		short run	long run	short run	long run			
				treated acres	untreated acres					consumer	producer	total
Foliar Treatments												
copper compounds	7	- 7	< 1	6 (*)[1]	0 (*)	*	*	*	*	0	101 (*)	101 (*)
fosetyl-Al	21	- 70	- 2	35 (1)	0 (*)	*	*	*	*	0	1,993 (*)	1,993 (*)
iprodione	50	- 18	- 6	- 192 (5)	56 (1)	8	2	- 1	*	- 15,463	- 17,809 (2)	- 33,273 (3)
maneb	43	57	- 15	- 612 (15)	167 (4)	20	4	- 3	*	- 45,427	- 44,502 (4)	- 89,929 (8)
vinclozolin	33	16	- 3	- 147 (4)	0 (*)	3	*	*	*	*	- 13,247 (1)	- 13,247 (1)
all foliar fungicides	93	- 88	- 27	- 635 (16)	535 (15)	115	15	- 11	- 2	- 160,095	- 126,778 (12)	- 286,874 (27)
Seed Treatments												
thiram	7	0	- 13	- 548 (13)	0 (*)	1	*	*	*	0	- 9,657 (*)	- 9,657 (*)
Preplant Treatments												
metalaxyl	19	- 60	- 1	11 (*)	0 (*)	*	*	*	*	0	533 (*)	533 (*)

* = change of less than 1%

[1] Numbers in parentheses are percentages. Below "Impact per Acre," they are expressed in terms of crop value per acre. Below "Total Impact," they are expressed in terms of total U.S. lettuce value.

growing season, the loss of maneb could increase farm-level prices 20%; the loss of iprodione could increase them 8%. In the long run, with greater acreage and other input use adjustment, the loss of any single fungicide would result in small farm-level price increases of 4% (for maneb) or less and output declines of 1% or less. Acreage previously treated with a lost material would bear the brunt of the producer loss, while returns on untreated acreage would increase slightly. Because of the price increases, consumers would bear part of the financial losses.

The loss of all foliar materials would cause long-run economic losses of about $290 million (27% of U.S. lettuce value), which is about twice the sum of banning each material individually. With an abrupt termination of the use of all materials, lettuce price could double in the short run. In the more likely case where acreage and other input use could adjust more fully, lettuce price would increase 15% and output would decline 2%. As a result of the increased cost of producing a pound of lettuce, the returns on the 93% of acreage previously treated with foliar fungicides would decline by an amount estimated at 16% of crop value. Returns would increase on the 7% of acreage not needing treatment with foliar fungicides. Consumers would lose $160 million, while producers lose $130 million (12% of U.S. crop value).

Losing the use of some fungicides would affect some states more than others and could encourage regional shifts in acreage and production because of differences in pest problems and pesticide use patterns (Table ECON11). Losing iprodione, maneb, or all foliars would have the largest impacts, primarily on eastern or southeastern production. The loss of iprodione would have its greatest negative effect on New York (48% of lettuce value), followed by New Jersey (10%) and Florida (3%). The loss of maneb would have its greatest negative impact on Florida (61% of lettuce value), followed by New York (14%) and Texas (8%); there would also be a small loss in California. The loss of all foliar fungicides would cause losses in all states, but

Table ECON11. Lettuce: economic impacts on current planted acreage, by state.

State	Foliar Materials						Seed Trmt.	Preplant
	copper	fosetyl-Al	iprodione	maneb	vinclozolin	all	thiram	metalaxyl
	----------Percent of Crop Value----------							
Arizona	*	*	*	2	*	- 23	*	*
California	*	*	- 1	- 2	*	- 9	*	*
Florida	*	*	- 3	- 61	*	- 63	- 15	*
New Jersey	*	*	- 10	4	- 2	- 36	- 10	*
New York	*	*	- 48	- 14	- 3	- 63	- 11	- 5
Ohio	*	*	- 1	*	*	- 23	- 3	*
Texas	*	*	*	- 8	*	- 49	*	- 10
Washington	*	*	- 1	*	- 2	- 6	- 7	*

* = less than 1%

the largest losses would occur in Florida (63% of lettuce value), New York (63%), Texas (49%), and New Jersey (36%). The loss of the seed treatment, thiram, would also cause losses in Florida (15%), New York (11%), and New Jersey (11%). The loss of metalaxyl would cause losses in Texas (10% of lettuce value) and New York (5%). In all of these cases, production would be encouraged in western states, which would suffer smaller losses or even have gains because of price increases, and discouraged in eastern states. Losing the use of copper compounds, fosetyl-Al, or vinclozolin would have minor regional effects.

Spinach

Spinach is produced for both fresh and processing (canning and freezing) markets. California and Texas are the two largest producing states, in terms of acreage, for both markets. These two states account for 70% of production for fresh market and 80% for processing use. California is the largest producing state for fresh market, with 60-65% of its acreage producing for that market. Texas is the largest producing state for processing, with 60-65% of its acreage producing for that market; however, many other small acreage states produce for local and seasonal markets, and often receive high prices.

Fungicide use patterns for spinach differ from those for lettuce and for the other four leafy greens. As with collards, kale, mustard greens, and turnip greens, spinach seed treatments are used more widely and foliar treatments less widely than on lettuce; virtually 100% of spinach acres receive seed treatments and 66% receive foliar treatments (Table ECON12). However, spinach acres receive a much higher proportion of preplant treatments with metalaxyl than any of the other five crops considered in this study: 76%. The primary foliar treatments are copper compounds (48% of acres treated) and fosetyl-Al (14% of acres treated). Of the seed treatments, captan is used on 80% and thiram on 24% of the acres; seed treatments including both materials are used on 4% of the acres.

The largest impact from the loss of any single chemical would occur with metalaxyl, because there is no good chemical alternative for preplant treatments--more than $15 million (19% of U.S. spinach value). The impact from losing metalaxyl would approach that from losing all foliar materials and would be greater than that from losing all seed treatments. In the short run, if use were abruptly terminated before a growing season began, spinach prices could increase 28%; but, in the long run, greater acreage and other input adjustment would result in price increases of 3% and output declines of 2%. In the long-run case, producers would bear most of the impact, about $13 million, but consumers would bear some of the impact due to higher prices. Producer losses on treated acreage would exceed 20% of per-acre crop value, on average.

The loss of all seed treatments would result in financial losses of about $6 million (8% of U.S. spinach value), while the loss of either captan or thiram, assuming the other is available, would result in financial losses of less than 1% of U.S. spinach value. This result indicates that captan and thiram are good alternatives to each other in most states. Without seed treatments, spinach prices could increase 6% in the short-run case. Greater adjustment in acreage and other input use would result in price increases and output decreases of less than 1% in the long run, and spinach producers would bear most of the impacts of losing seed treatments. The loss of all foliar fungicides would result in financial losses of about $19 million (24% of U.S. spinach

Table ECON12. Spinach: economic impacts of bans of selected fungicides.

Fungicide	Acres treated (%)	Impact per Acre				Price Change (%)		Output Change (%)		Total Impact (long-run) ($1,000)		
		cost change ($/A)	yield change (%/A)	total monetary ($/A)		short run	long run	short run	long run			
				treated acres	untreated acres					consumer	producer	total
Foliar Treatments												
copper compounds	48	- 10	- 22	- 240 (13)[1]	350 (2)	12	2	- 7	- 1	- 1,306	- 3,746 (15)	- 5,052 (6)
fosetyl-Al	14	- 59	- 34	- 852 (31)	0 (*)	7	*	- 5	*	0	- 4,622 (5)	- 4,622 (5)
all foliar fungicides	61	- 34	- 37	- 723 (35)	76 (4)	32	4	- 18	- 3	- 3,070	- 16,049 (20)	- 19,119 (24)
Seed Treatments												
captan	80	*	*	* (*)	0 (*)	*	*	*	*	0	- 2 (*)	- 2 (*)
thiram	24	*	*	- 16 (1)	0 (*)	*	*	*	*	0	- 152 (*)	- 152 (*)
all seed treatments	100	*	- 5	- 158 (8)	0 (*)	6	*	- 4	*	0	- 6,120 (8)	- 6,120 (8)
Preplant Treatments												
metalaxyl	76	- 53	- 27	- 469 (22)	40 (2)	28	3	- 16	- 2	- 2,031	- 13,551 (17)	- 15,581 (19)

* = change of less than 1%

[1] Numbers in parentheses are percentages. Below "Impact per Acre," they are expressed in terms of crop value per acre. Below "Total Impact," they are expressed in terms of total U.S. lettuce value.

value). Prices could increase 32% in the short run. In the long run, price would increase 4% and output would decline 3%. Producers would lose about $17 million and consumers about $3 million in the long run. Financial losses on treated acreage could be severe, approaching 35% of crop value. The financial impact from losing the use of either the copper compounds or fosetyl-Al would be about 25% of that from losing all foliar treatments: $4.6 million (5% of U.S. spinach value) for fosetyl-Al and $5.1 million (6% of U.S. spinach value) for copper compounds. This result indicates that the foliar materials could be used as alternatives to each other on some, but not all, acres, and that yield losses would generally occur. In many cases, copper compounds and fosetyl-Al would not be effective alternatives to each other. While prices could increase 5-10% in the short-run situation, long-run price increases and output declines would be 2% or less. Financial losses could be on the order of 30% of crop value on treated acreage for fosetyl-Al and 15% for copper compounds.

In general, the loss of fungicides would discourage spinach production in the southern and eastern states and encourage production in the western states (Table ECON13). However, California production would bear the brunt of the economic impact if the use of fosetyl-Al were

Table ECON13. Spinach: economic impacts on current planted acreage, by state.

State	Foliar Materials			Seed Treatments			Preplant
	copper	fosetyl-Al	all	captan	thiram	all	metalaxyl
	--Percent of Crop Value--						
Arkansas	- 8	*	- 70	*	*	- 20	- 35
Arizona	1	*	2	*	*	- 7	1
California	2	- 15	- 14	*	*	*	- 14
Delaware	- 4	- 2	- 53	*	*	- 15	- 9
Florida	1	*	3	*	*	- 20	2
Georgia	- 51	*	- 88	*	*	- 10	- 45
Maryland	- 3	- 2	- 27	*	*	- 12	- 22
North Carolina	2	*	4	*	- 11	- 11	3
New Jersey	- 4	- 2	- 53	*	*	- 15	- 17
New York	10	*	- 15	*	*	- 25	- 11
Ohio	- 6	*	- 57	*	*	- 12	- 47
Oklahoma	*	*	*	*	*	- 15	2
South Carolina	- 10	*	- 35	*	*	- 60	- 49
Tennessee	2	*	4	*	*	- 5	3
Texas	- 23	*	- 21	*	*	- 2	- 25
Virginia	- 10	*	- 35	*	*	- 20	- 25

* = less than 1%

lost (15% of spinach value). With the loss of copper compounds, Georgia (51% of spinach value), South Carolina (10%), Texas (23%), and Virginia (20%) would suffer the largest proportional economic losses. Because of the large impact on Texas production, losing copper compounds would have a greater impact on production for processing than for fresh market. If all foliar materials were lost, Arkansas (70% of spinach value), Delaware (53%), Georgia (88%), New Jersey (53%), and Ohio (51%) would incur particularly large proportional economic losses.

The loss of either captan or thiram as a seed treatment would have little impact on any state, except in the case of thiram in North Carolina (financial losses of 11% of spinach value). The loss of both materials would cause the worst impacts on southern and eastern production, with little impact on western (California and Arizona) production. The adverse impact of losing all seed-treatment fungicides would be much worse on fresh market than on processing production, because of relatively small impacts in California and Texas.

The loss of metalaxyl, primarily applied preplant, would hit some southern and eastern states such as Arkansas (35% of crop value), Georgia (45%), Ohio (47%), and South Carolina (49%) with more severe economic losses than the western states. Even so, California production would suffer substantial financial losses (14% of spinach value) without the use of metalaxyl.

Implications for the Regulatory Process

Previous NAPIAP assessment studies, including those for corn, soybeans, and cotton, have shown that some pesticide regulatory decisions could better be made in the context of a "cluster" or "commodity" approach rather than the traditional approach of considering one material at a time as risk issues arise (Osteen, 1993 and Osteen and Kuchler, 1987). The "cluster" or "commodity" approach considers the risks and benefits of all major alternatives for a pest problem before making a final decision. The availability of two or more alternatives of comparable effectiveness for a pest problem creates such a case. The "cluster" approach can help the Environmental Protection Agency to reduce risk more cost-effectively by avoiding decisions that: 1) cause economic losses while increasing environmental or health risks or 2) increase the future economic benefits of higher-risk alternatives by removing lower-risk alternatives when several effective alternatives are available and economic losses of removing one alternative would be low. Such an approach would also identify cases where managing the use of a group of alternatives would reduce risk more cost-effectively than banning some of the alternatives.

This assessment shows that regulatory decisions concerning seed-treatment fungicides for leafy green vegetables, with the exception of lettuce, would be well-suited to a "cluster approach." Previous assessments have shown this also to be true for such major use crops as corn and cotton. The reason is that seed treatments are very valuable in production, but the individual fungicides are good alternatives to each other in many situations. Banning one of them would significantly increase the value of the remaining materials.

For foliar fungicides, the need for a "cluster approach" is less compelling than for seed treatments, because foliar materials often have unique niches for which good alternatives are not available. As a result, one, two, or three materials may have significant benefits that are

independant of actions to remove alternatives. Examples include copper compounds on collards, mustard greens, turnip greens, and spinach; iprodione and vinclozolin on spinach; and maneb on kale and lettuce. The preplant material, metalaxyl, also fills a unique, high-value role for spinach production. However, a full accounting of the risks and benefits of the alternatives, if any are available, is needed to make a wise decision about whether to continue the registration of any one of these materials.

Conclusions

In general, the economic losses from banning all foliar or all seed-treatment fungicides would be much larger than those from banning individual materials. In the case of lettuce, seed-treatment fungicides are not widely used, and the impact of banning them would be relatively small. Banning all foliar fungicides would cause the biggest impacts on collards, kale, turnip greens, lettuce, and spinach, while banning all seed treatments would cause the largest impact on turnip greens. However, the impact of banning the use of metalaxyl, the only preplant treatment, on spinach would be greater than that from banning seed treatments and slightly less than that from banning foliar treatments.

The impact of banning any single seed-treatment fungicide on any one of the crops would be small. The reason is that the individual materials appear to be good alternatives to each other in many circumstances. Banning one of them would have little impact, but would significantly increase the benefits of the remaining materials.

Foliar materials used on leafy greens often fill unique niches for which alternatives are much less effective or are not available. For example, copper compounds on collards, mustard greens, turnip greens, and spinach; fosetyl-Al on spinach; iprodione and vinclozolin on lettuce; and maneb on kale and lettuce have substantial benefits for those crops.

Regulatory actions on leafy green fungicides would generally cause proportionally larger economic losses in southern and eastern production than in western production. As a result, regulatory actions would tend to discourage production in the east and south more than in the west. However, one exception is that the greatest impact from losing fosetyl-Al for spinach production would be in California.

Based on the analyses of lettuce and spinach, price increases caused by pesticide cancellations where existing stocks can be used, or by pesticide phaseouts, would generally not be noticeable (5% or more) unless all foliar fungicides were banned. A major exception would be metalaxyl use on spinach. If collards, kale, mustard greens, and turnip greens have demand and supply relationships similar to lettuce and spinach, bans of all foliar or seed-treatment fungicides would probably be required to cause noticeable long-run price increases. In cases where prices increase, consumers and some growers, specifically users of the pesticide, would bear a major portion of the impact. Growers who do not use the regulated pesticide would gain from price increases. In those cases where actions have little impact on price, the impacts will be concentrated on growers who use the pesticide in question.

Suspensions, or abrupt terminations, of the use of some active ingredients could result in large short-term price increases until growers adjust acreage and other input use. Examples include

maneb or iprodione use on lettuce and copper compounds or fosetyl-Al use on spinach. During the period of adjustment, consumers could bear a much larger portion of the cost than after cancellations, where existing stocks can be used, or phaseouts. Conceivably, bans of copper compounds on collards, mustard greens and turnip greens; maneb on kale; or benomyl on turnip greens could result in noticeable short-term price increases.

This assessment shows that regulatory decisions concerning seed-treatment fungicides for leafy green vegetables, with the exception of lettuce, would be well-suited to a "cluster approach." The reason is that seed treatments are very valuable in production, but the individual fungicides are good alternatives to each other in many situations. For foliar fungicides, the need for a "cluster approach" is less compelling than for seed treatments, because foliar materials often have unique niches for which cost-effective alternatives are not available. As a result, the individual materials may have substantial benefits that are independent of actions to remove alternatives.

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APPENDIX

Pesticide Impact Data

TABLE 1. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Collards
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
benomyl (T)	OH	0.0006	ST	1	Seedling diseases	100	230	0.14
					U.S. Totals (of states reporting) →			0.14
captan	AL	0.002	ST	1	Seedling diseases	100	1,974	3.95
captan	AZ	0.002	ST	1	Seedling diseases	100	800	1.60
captan	CA	0.002	ST	1	Seedling diseases	100	1,022	2.04
captan	FL	0.002	ST	1	Seedling diseases	100	1,500	3.00
captan	GA	0.002	ST	1	Seedling diseases	100	8,455	16.91
captan	MD	0.002	ST	1	Seedling diseases	100	511	1.02
captan	NJ	0.002	ST	1	Seedling diseases	100	913	1.83
captan	NY	0.002	ST	1	Seedling diseases	50	100	0.20
captan	OK	0.002	ST	1	Seedling diseases	100	375	0.75
captan	PA	0.002	ST	1	Seedling diseases	100	400	0.80
captan	SC	0.002	ST	1	Seedling diseases	90	1,215	2.43
captan	TX	0.002	ST	1	Seedling diseases	50	150	0.30
					U.S. Totals (of states reporting) →			34.83
copper	AL	1.0	F	2	Downy mildew, Alternaria leaf spot, black rot	50	987	1,974
copper	CA	1.0	F	2	Downy mildew, Alternaria leaf spot	5	51	102
copper (S)	FL	0.5	F	2	Alternaria leaf spot, downy mildew	10	150	150
copper	GA	1.0	F	4	Downy mildew, Alternaria leaf spot, black rot	90	7,610	30,438
copper	MD	1.0	F	2	Downy mildew, Alternaria leaf spot, black rot	10	51	102

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1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	NJ	1.0	F	2	Downy mildew, Alternaria leaf spot, black rot	5	46	91
copper	NY	1.0	F	2	Downy mildew, Alternaria leaf spot, black rot	66	132	264
copper (S)	OH	0.5	F	2	Downy mildew	90	207	207
copper (S)	OK	0.5	F	2	Downy mildew, Alternaria leaf spot, black rot	10	38	38
copper	PA	1.0	F	2	Downy mildew	25	100	200
copper	SC	1.0	F	3	Downy mildew, Alternaria leaf spot, black rot	40	540	1,620
copper (S)	TN	0.5	F	1.5	Downy mildew, Alternaria leaf spot	10	60	45
copper (S)	TX	0.5	F	1	Downy mildew, Alternaria leaf spot, black rot	40	120	60
copper	TX	1.5	F	1	Downy mildew, Alternaria leaf spot, black rot	60	180	270
copper	VA	1.0	F	2	Downy mildew, Alternaria leaf spot	10	60	120
					U.S. Totals (of states reporting) →			35,681
fosetyl-Al	AZ	1.6	F	2	Downy mildew	5	40	128
fosetyl-Al	CA	2.4	F	2	Downy mildew, Phytophthora	5	51	245
fosetyl-Al	FL	1.6	F	1	Downy mildew	1	15	24
fosetyl-Al	GA	1.6	F	1	Downy mildew	10	846	1,353
fosetyl-Al	MD	1.6	F	2	Downy mildew	10	51	164
fosetyl-Al	NJ	1.6	F	2	Downy mildew	5	46	146
fosetyl-Al	OH	1.6	F	2	Downy mildew	55	127	405
					U.S. Totals (of states reporting) →			2,465
sulfur	CA	4.0	F	2	Powdery mildew	15	153	1,226

TABLE 1. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Collards
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
sulfur	FL	2.4	F	1	Alternaria leaf spot	5	75	180
sulfur (C)	FL	3.13	F	2	Alternaria leaf spot, downy mildew	10	150	939
sulfur (C)	OH	3.13	F	2	Downy mildew	90	207	1,296
sulfur (C)	OK	3.13	F	2	Alternaria leaf spot, downy mildew	10	38	238
sulfur	SC	4.0	F	2	Powdery mildew	5	68	540
sulfur (C)	TN	3.13	F	1.5	Downy mildew, Alternaria leaf spot	10	60	282
sulfur (C)	TX	3.13	F	1	Downy mildew, Alternaria leaf spot, black rot	40	120	376
					U.S. Totals (of states reporting) →			**5,076**
thiram	NC	0.003	ST	1	Seedling diseases	90	1,980	5.9
thiram	NY	0.003	ST	1	Seedling diseases	50	100	0.3
thiram (B)	OH	0.003	ST	1	Seedling diseases	100	230	0.7
thiram	TN	0.003	ST	1	Seedling diseases	100	600	1.8
thiram	TX	0.003	ST	1	Seedling diseases	50	150	0.5
thiram	VA	0.003	ST	1	Seedling diseases, Rhizoctonia	100	600	1.8
					U.S. Totals (of states reporting) →			**11.0**
					COLLARDS SEED PRODUCTION			
iprodione	WA	1.0	F	1	Alternaria leaf spot, white mold	100	300	300.0
metalaxyl (T)	WA	0.0006	ST	1	Seedling diseases, downy mildew	100	300	0.2

TABLE 1. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Collards
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
thiram (R)	WA	0.003	ST	1	Seedling diseases	100	300	0.9

[1] Used in combination with: (B) = benomyl, (C) = copper, (R) = metalaxyl, (S) = sulfur, and (T) = thiram, each of which should be consulted for use rates, target pests and total usage of the combination chemical.
[2] Fungicide timing: F = foliar, PP = preplant, ST = seed treatment.

TABLE 2. Impact of the Loss of Individual Fungicides on the Production of Collards
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
benomyl	ST	OH	None	100	230	0	0
			U.S. Totals (of states reporting) →	**1.073**	**230**	**0**	**0**
captan	ST	AL	thiram (100)	100	1,974	0	0
captan	ST	AZ	thiram (100)	100	800	0	0
captan	ST	CA	thiram (100)	100	1,022	0	0
captan	ST	FL	thiram (100)	100	1,500	0	0
captan	ST	GA	thiram (100)	100	8,455	0	0
captan	ST	MD	thiram (100)	100	511	0	0
captan	ST	NJ	thiram (100)	100	913	0	0
captan	ST	NY	thiram (50)	50	100	0	0
captan	ST	OK	thiram (100)	100	375	0	0
captan	ST	PA	thiram (100)	100	400	0	0
captan	ST	SC	thiram (90)	90	1,215	0	0
captan	ST	TX	thiram (50)	50	150	0	0
			U.S. Totals (of states reporting) →	**81.3**	**17,415**	**0**	**0**
copper	F	AL	None	50	987	- 30	- 3,553,200
copper	F	CA	None	5	51	0	0
copper	F	GA	fosetyl-Al (65)	90	7,610	- 40	- 26,633,250
copper	F	MD	fosetyl-Al (10)	10	51	0	0
copper	F	NJ	fosetyl-Al (5)	5	46	- 5	- 27,390

TABLE 2. Impact of the Loss of Individual Fungicides on the Production of Collards
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper	F	NY	None	66	132	- 20	- 475,200
copper	F	PA	fosetyl-Al (10)	25	100	- 3	- 51,000
copper	F	SC	fosetyl-Al (5)	40	540	- 10	- 621,000
copper	F	TX	None	60	180	- 50	- 1,800,000
copper	F	VA	fosetyl-Al (10)	10	60	0	0
			U.S. Totals (of states reporting) →	**45.5**	**9,756**	**- 12.8**	**- 33,161,040**
copper + sulfur	F	FL	fosetyl-Al (1)	10	150	- 15	- 450,000
copper + sulfur	F	OH	fosetyl-Al (35)	90	207	- 5	- 207,000
copper + sulfur	F	OK	None	10	38	- 5	- 30,000
copper + sulfur	F	TN	None	10	60	- 5	- 36,000
copper + sulfur	F	TX	None	40	120	- 50	- 1,200,000
			U.S. Totals (of states reporting) →	**2.7**	**575**	**- 0.7**	**-1,923,000**
fosetyl-Al	F	AZ	None	5	40	- 5	- 26,000
fosetyl-Al	F	CA	None	5	51	- 10	- 102,200
fosetyl-Al	F	FL	copper + sulfur (1)	1	15	0	0
fosetyl-Al	F	GA	copper (10)	10	846	- 25	- 1,849,531
fosetyl-Al	F	MD	None	10	51	- 10	- 56,210
fosetyl-Al	F	NJ	copper (5)	5	46	- 5	- 27,390
fosetyl-Al	F	OH	copper + sulfur (45)	55	127	- 15	- 379,500
			U.S. Totals (of states reporting) →	**5.482**	**1,175**	**- 0.9**	**- 2,440,831**

TABLE 2. Impact of the Loss of Individual Fungicides on the Production of Collards
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
sulfur	F	CA	None	15	153	- 17.5	- 536,550
sulfur	F	FL	copper (5)	5	75	- 5	- 75,000
sulfur	F	SC	None	5	68	- 3	- 23,288
U.S. Totals (of states reporting) →				**1.4**	**296**	**- 0.3**	**- 634,838**
thiram	ST	NC	captan (90)	90	1,980	- 12.5	- 2,846,250
thiram	ST	NY	captan (50)	50	100	0	0
thiram	ST	OH	captan (100)	100	230	0	0
thiram	ST	TN	captan (100)	100	600	0	0
thiram	ST	TX	captan (50)	50	150	0	0
thiram	ST	VA	captan (100)	100	600	0	0
U.S. Totals (of states reporting)				**17.1**	**3,660**	**- 1.1**	**- 2,846,250**
COLLARDS SEED PRODUCTION							
iprodione	F	WA	None	100	300	- 30	- 153,000 lb seed
metalaxyl + thiram	ST	WA	None	100	300	- 6	- 30,600 lb seed

1 Fungicide application timing: F = foliar, PP = preplant, ST = seed treatment
2 Alternatives are other fungicides or nonpesticide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide, unless there is nontreatment or overlap treatment on the formerly treated acreage.
3 Yield impacts are plus (+) or minus (-) and represent the percent yield change (up to maximum of 100%) on the acreage presently treated with the "lost" fungicide. U.S. totals are based on the 1992 planted acreage in each reporting state. Yield figures (for greens) for Washington state are not included because crop production there is only for seed production.

TABLE 3. Impact of the Loss of Fungicide Groups on the Production of Collards
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Foliar fungicides	AL	None	50	987	- 30	- 3,553,200
Foliar fungicides	AZ	None	5	40	- 5	- 26,000
Foliar fungicides	CA	None	25	256	- 20	- 1,022,000
Foliar fungicides	FL	Premature harvest (8)	16	240	- 40	- 1,920,000
Foliar fungicides	GA	None	100	8,455	- 75	- 55,485,937
Foliar fungicides	MD	None	20	102	- 15	- 168,630
Foliar fungicides	NJ	None	10	91	- 10	- 109,560
Foliar fungicides	NY	Premature harvest (20), trimming (66), longer rotation (66)	66	132	- 20	- 475,200
Foliar fungicides	OH	None	100	230	- 25	- 1,150,000
Foliar fungicides	OK	Premature harvest (5)	10	38	- 5	- 30,000
Foliar fungicides	PA	None	25	100	- 10	- 170,000
Foliar fungicides	SC	None	45	608	- 30	- 2,095,875
Foliar fungicides	TN	None	10	60	- 5	- 36,000
Foliar fungicides	TX	None	100	300	- 50	- 3,000,000
Foliar fungicides	VA	None	10	60	- 10	- 90,000
		U.S. Totals (of states reporting) →	**54.6**	**11,698**	**- 26.8**	**- 69,332,402**
Seed-treatment fungicides	AL	None	100	1,974	- 20	- 4,737,600
Seed-treatment fungicides	AZ	None	100	800	- 7	- 728,000
Seed-treatment fungicides	CA	None	100	1,022	0	0

TABLE 3. Impact of the Loss of Fungicide Groups on the Production of Collards
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Seed-treatment fungicides	FL	None	100	1,500	- 7	- 2,100,000
Seed-treatment fungicides	GA	None	100	8,455	- 10	- 7,398,125
Seed-treatment fungicides	MD	None	100	511	- 12.5	- 702,625
Seed-treatment fungicides	NC	None	90	1,980	- 12.5	- 2,846,250
Seed-treatment fungicides	NJ	None	100	913	- 10	- 1,095,600
Seed-treatment fungicides	NY	None	100	200	- 15	- 540,000
Seed-treatment fungicides	OH	None	100	230	- 10	- 460,000
Seed-treatment fungicides	OK	None	100	375	- 10	- 600,000
Seed-treatment fungicides	PA	None	100	400	- 10	- 680,000
Seed-treatment fungicides	SC	None	90	1,215	- 20	- 2,794,500
Seed-treatment fungicides	TN	None	100	600	- 1	- 120,000
Seed-treatment fungicides	TX	None	100	300	- 1	- 36,000
Seed-treatment fungicides	VA	None	100	600	- 10	- 900,000
		U.S. Totals (of states reporting) →	**98.3**	**21,075**	**- 9.9**	**- 25,738,700**
		COLLARDS SEED PRODUCTION				
Foliar fungicides	WA	None	100	300	- 30	- 153,000 lb seed
Seed-treatment fungicides	WA	None	100	300	- 6	- 30,600 lb seed

[1] Alternatives are other fungicides, fungicide groups, or nonfungicide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide group that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide group, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[2] Yield impacts are plus (+) and minus (-) and represent the percent yield change (up to a maximum of 100%) on the acreage presently treated with the "lost"

TABLE 4. Nonpesticide Control Practices for Pests on Collards
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Acreage Where Practiced	Acreage where Practiced
Rotation	AL	Seedling diseases	90	1,777
Rotation	AZ	Seedling diseases	100	800
Rotation	CA	Seedling diseases	100	1,022
Rotation	FL	Seedling diseases	80	1,200
Rotation	GA	Seedling diseases	100	8,455
Rotation	MD	Seedling diseases	100	511
Rotation	NC	Seedling diseases	100	2,200
Rotation	NJ	Seedling diseases, black rot	100	913
Rotation	NY	Seedling diseases	100	200
Rotation	OH	Seedling diseases	100	230
Rotation	OK	Seedling diseases, black rot	100	375
Rotation	PA	Seedling diseases	40	160
Rotation	SC	Seedling diseases	90	1,215
Rotation	TN	Downy mildew, Alternaria leaf spot	20	120
Rotation	TX	Seedling diseases, Alternaria leaf spot, black rot	100	300
Rotation	VA	Seedling diseases, Rhizoctonia	100	600
		U.S. Totals (of states reporting) →	**93.7**	**20,078**
		COLLARDS SEED PRODUCTION		
Rotation	WA	Seedling diseases, white mold	100	300

[1] Rotation = in the preceding year, the percentage of the current crop acreage (1992) that had an alternate crop on it.

TABLE 5. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Kale 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
benomyl (T)	OH	0.001	ST	1	Seedling diseases, black leg	100	155	0.16
					U.S. Totals (of states reporting) →			**0.16**
captan	AZ	0.003	ST	1	Seedling diseases	100	188	0.56
captan	CA	0.003	ST	1	Seedling diseases	100	804	2.41
captan	FL	0.003	ST	1	Seedling diseases	100	341	1.02
captan	GA	0.003	ST	1	Seedling diseases	100	2,610	7.83
captan	MD	0.003	ST	1	Seedling diseases	100	615	1.85
captan	NJ	0.003	ST	1	Seedling diseases	100	433	1.30
captan	NY	0.003	ST	1	Seedling diseases	50	38	0.11
captan	OK	0.003	ST	1	Seedling diseases	100	140	0.42
captan	PA	0.003	ST	1	Seedling diseases	100	200	0.60
captan	SC	0.003	ST	1	Seedling diseases	100	140	0.42
captan	TX	0.003	ST	1	Seedling diseases	50	200	0.60
captan	VA	0.003	ST	1	Seedling diseases	100	500	1.50
					U.S. Totals (of states reporting) →			**18.63**
copper	GA	1.0	F	1	Downy mildew, Alternaria leaf spot	1	26	26
copper	NY	1.0	F	2.5	Alternaria leaf spot, downy mildew	66	50	125
copper (S)	OH	0.5	F	2	Downy mildew	90	140	140
copper	SC	1.0	F	2	Downy mildew, Alternaria leaf spot	10	14	28
copper	TX	1.5	F	1	Downy mildew, Alternaria leaf spot	20	80	120

TABLE 5. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Kale 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	VA	1.0	F	2	Alternaria leaf spot, downy mildew, black rot	20	100	200
					U.S. Totals (of states reporting) →			**639**
fosetyl-Al	AZ	1.6	F	2	Downy mildew	5	9	30
fosetyl-Al	CA	2.4	F	2	Downy mildew	20	161	772
fosetyl-Al	GA	1.6	F	1	Downy mildew	2	52	84
fosetyl-Al	MD	1.6	F	2	Downy mildew	5	31	98
fosetyl-Al	NJ	1.6	F	2	Downy mildew	5	22	69
fosetyl-Al	OH	1.6	F	2	Downy mildew	55	85	273
					U.S. Totals (of states reporting) →			**1,326**
maneb	AZ	1.6	F	2	Downy mildew, Alternaria leaf spot	20	38	120
maneb	CA	1.6	F	2	Downy mildew, Alternaria leaf spot	40	322	1,029
maneb	FL	1.6	F	2	Downy mildew, Alternaria leaf spot	5	17	55
maneb	GA	1.6	F	4	Downy mildew, Alternaria leaf spot	97	2,532	16,203
maneb	MD	1.6	F	2	Downy mildew, Alternaria leaf spot	45	277	886
maneb	NJ	1.6	F	2	Alternaria leaf spot, downy mildew	45	195	624
maneb	SC	1.6	F	2	Downy mildew, Alternaria leaf spot	50	70	224
maneb	TN	1.6	F	2	Downy mildew, Alternaria leaf spot	80	56	179
maneb	TX	1.6	F	2	Downy mildew, Alternaria leaf spot	65	260	832
maneb	VA	1.6	F	2	Alternaria leaf spot, downy mildew	30	150	480
					U.S. Totals (of states reporting) →			**20,631**

TABLE 5. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Kale
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
sulfur	CA	4.0	F	2	Powdery mildew	5	40	322
sulfur (C)	OH	3.13	F	2	Downy mildew	90	140	876
					U.S. Totals (of states reporting) →			**1,198**
thiram	NC	0.004	ST	1	Seedling diseases	90	450	1.8
thiram	NY	0.004	ST	1	Seedling diseases	50	38	0.2
thiram (B)	OH	0.004	ST	1	Seedling diseases	100	155	0.6
thiram	TN	0.004	ST	1	Seedling diseases	100	70	0.3
thiram	TX	0.004	ST	1	Seedling diseases	50	200	0.8
					U.S. Totals (of states reporting) →			**3.7**
					KALE SEED PRODUCTION			
iprodione	WA	1.0	F	1	White mold, Alternaria leaf spot	100	400	400.0
maneb	WA	1.6	F	1	Downy mildew, Alternaria leaf spot	10	40	64.0
metalaxyl (T)	WA	0.001	ST	1	Seedling diseases	100	400	0.4
thiram (R)	WA	0.005	ST	1	Seedling diseases	100	400	2.0

[1] Used in combination with: (B) = benomyl, (C) = copper, (R) = metalaxyl, (S) = sulfur, and (T) = thiram, each of which should be consulted for use rates, target pests and total usage of the combination chemical.
[2] Fungicide timing: F = foliar, PP = preplant, ST = seed treatment.

TABLE 6. Impact of the Loss of Individual Fungicides on the Production of Kale
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
benomyl	ST	OH	None	100	155	0	0
			U.S. Totals (of states reporting) →	**2.2**	**155**	**0**	**0**
captan	ST	AZ	thiram (100)	100	188	0	0
captan	ST	CA	thiram (100)	100	804	0	0
captan	ST	FL	thiram (100)	100	341	0	0
captan	ST	GA	thiram (100)	100	2,610	0	0
captan	ST	MD	thiram (100)	100	615	0	0
captan	ST	NJ	thiram (100)	100	433	0	0
captan	ST	NY	thiram (50)	50	38	0	0
captan	ST	OK	thiram (100)	100	140	0	0
captan	ST	PA	thiram (100)	100	200	0	0
captan	ST	SC	thiram (100)	100	140	0	0
captan	ST	TX	thiram (50)	50	200	0	0
captan	ST	VA	thiram (100)	100	500	0	0
			U.S. Totals (of states reporting) →	**86.6**	**6,209**	**0**	**0**
copper	F	GA	fosetyl-Al (1)	1	26	- 5	- 14,681
copper	F	NY	None	66	50	- 10	- 89,100
copper	F	SC	maneb (10)	10	14	5	8,050
copper	F	TX	maneb (20)	20	80	0	0

TABLE 6. Impact of the Loss of Individual Fungicides on the Production of Kale
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper	F	VA	fosetyl-Al (5), maneb (15)	20	100	0	0
			U.S. Totals (of states reporting) →	**3.8**	**270**	**- 0.1**	**- 95,731**
copper + sulfur	F	OH	fosetyl-Al (45)	90	140	- 10	- 292,950
			U.S. Totals (of states reporting) →	**1.9**	**140**	**- 0.3**	**- 292,950**
fosetyl-Al	F	AZ	maneb (5)	5	9	0	0
fosetyl-Al	F	CA	maneb (12)	20	161	0	0
fosetyl-Al	F	GA	maneb (2)	2	52	0	0
fosetyl-Al	F	MD	maneb (5)	5	31	- 5	- 14,606
fosetyl-Al	F	NJ	maneb (5)	5	22	0	0
fosetyl-Al	F	OH	copper + sulfur (55)	55	85	- 15	- 268,538
			U.S. Totals (of states reporting) →	**5.0**	**360**	**- 0.3**	**- 283,144**
maneb	F	AZ	fosetyl-Al (5)	20	38	- 5	- 20,280
maneb	F	CA	None	40	322	- 20	- 1,350,720
maneb	F	FL	Increase acreage (5)	5	17	- 5	- 9,378
maneb	F	GA	fosetyl-Al (22), copper (74)	97	2,532	- 25	- 7,120,406
maneb	F	MD	fosetyl-Al (20)	45	277	- 10	- 262,913
maneb	F	NJ	None	45	195	- 5	- 107,168
maneb	F	SC	copper (45)	50	70	- 10	- 80,500
maneb	F	TN	None	80	56	- 15	- 100,800

TABLE 6. Impact of the Loss of Individual Fungicides on the Production of Kale
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
maneb	F	TX	fosetyl-Al (10), copper (55)	65	260	- 10	- 598,000
maneb	F	VA	fosetyl-Al (25), copper (5)	30	150	- 5	- 75,000
			U.S. Totals (of states reporting) →	**54.6**	**3,916**	**- 10.2**	**- 9,725,163**
sulfur	F	CA	None	5	40	- 10	- 84,420
			U.S. Totals (of states reporting) →	**0.6**	**40**	**- 0.1**	**- 84,420**
thiram	ST	NC	captan (90)	90	450	- 12.5	- 618,750
thiram	ST	NY	captan (50)	50	38	0	0
thiram	ST	OH	captan (100)	100	155	0	0
thiram	ST	TN	captan (100)	100	70	0	0
thiram	ST	TX	captan (50)	50	200	0	0
			U.S. Totals (of states reporting) →	**12.7**	**913**	**- 0.7**	**- 618,750**
KALE SEED PRODUCTION							
iprodione	F	WA	None	100	400	- 25	- 120,000 lb seed
maneb	F	WA	None	10	40	- 5	- 2,400 lb seed
metalaxyl + thiram	ST	WA	captan (100)	100	400	- 5	- 24,000 lb seed

[1] Fungicide application timing: F = foliar, PP = preplant, ST = seed treatment

[2] Alternatives are other fungicides or nonpesticide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[3] Yield impacts are plus (+) or minus (-) and represent the percent yield change (up to maximum of 100%) on the acreage presently treated with the "lost" fungicide. U.S. totals are based on the 1992 planted acreage in each reporting state. Yield figures (for greens) for Washington state are not included because crop production there is only for seed production.

TABLE 7. Impact of the Loss of Fungicide Groups on the Production of Kale
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Foliar fungicides	AZ	None	25	47	- 7	- 35,489
Foliar fungicides	CA	None	65	523	- 20	- 2,194,920
Foliar fungicides	FL	None	5	17	- 5	- 9,378
Foliar fungicides	GA	None	100	2,610	- 85	- 24,958,125
Foliar fungicides	MD	None	50	308	- 13	- 379,762
Foliar fungicides	NJ	None	50	217	- 5	- 119,075
Foliar fungicides	NY	None	66	50	- 10	- 89,100
Foliar fungicides	OH	None	100	155	- 20	-651,000
Foliar fungicides	SC	None	60	84	- 10	- 96,600
Foliar fungicides	TN	None	80	56	- 15	- 100,800
Foliar fungicides	TX	Premature harvest (85)	85	340	- 30	- 2,346,000
Foliar fungicides	VA	Premature harvest (30)	50	250	- 25	- 625,000
		U.S. Totals (of states reporting) →	**64.9**	**4,655**	**- 33.3**	**- 31,605,249**
Seed-treatment fungicides	AZ	None	100	188	- 7	- 141,957
Seed-treatment fungicides	CA	None	100	804	0	0
Seed-treatment fungicides	FL	None	100	341	- 7	- 262,570
Seed-treatment fungicides	GA	None	100	2,610	- 10	- 2,936,250
Seed-treatment fungicides	MD	None	100	615	- 13	- 759,525
Seed-treatment fungicides	NC	None	90	450	- 13	- 643,500
Seed-treatment fungicides	NJ	None	100	433	- 10	- 476,300

TABLE 7. Impact of the Loss of Fungicide Groups on the Production of Kale
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Seed-treatment fungicides	NY	None	100	75	- 25	- 337,500
Seed-treatment fungicides	OH	None	100	155	- 10	- 325,500
Seed-treatment fungicides	OK	None	100	140	- 10	-224,000
Seed-treatment fungicides	PA	None	100	200	- 10	- 340,000
Seed-treatment fungicides	SC	None	100	140	- 25	- 402,500
Seed-treatment fungicides	TN	None	100	70	- 1	- 8,400
Seed-treatment fungicides	TX	None	100	400	- 1	- 92,000
Seed-treatment fungicides	VA	None	100	500	- 10	- 500,000
		U.S. Totals (of states reporting) →	**99.3**	**7,121**	**- 7.8**	**- 7,450,002**
		KALE SEED PRODUCTION				
Foliar fungicides	WA	None	100	400	- 25.5	- 122,400 lb seed
Seed-treatment fungicides	WA	None	100	400	- 5	- 24,000 lb seed

[1] Alternatives are other fungicides, fungicide groups, or nonfungicide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide group that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide group, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[2] Yield impacts are plus (+) and minus (-) and represent the percent yield change (up to a maximum of 100%) on the acreage presently treated with the "lost" fungicide group. U.S. totals are based on 1992 planted acreage in each reporting state.

TABLE 8. Nonpesticide Control Practices for Pests on Kale
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Acreage Where Practiced	Acreage where Practiced
Rotation	AZ	Seedling diseases	100	188
Rotation	CA	Seedling diseases	100	804
Rotation	FL	Seedling diseases	80	273
Totation	GA	Seedling diseases	100	2,610
Rotation	MD	Seedling diseases	100	615
Rotation	NC	Seedling diseases	100	500
Rotation	NJ	Seedling diseases, black rot	100	433
Rotation	NY	Seedling diseases	100	75
Rotation	OH	Seedling diseases, black leg	100	155
Rotation	OK	Seedling diseases	90	126
Rotation	PA	Seedling diseases, black rot	40	80
Rotation	SC	Seedling diseases	100	140
Rotation	TN	Downy mildew, Alternaria leaf spot	20	14
Rotation	TX	Seedling diseases	100	400
Rotation	VA	Seedling diseases	100	500
		U.S. Totals (of states reporting) →	**96.4**	**6,913**
		KALE SEED PRODUCTION		
Rotation	WA	Seedling diseases, white mold	100	400

[1] Rotation = in the preceding year, the percentage of the current crop acreage (1992) that had an alternate crop on it.

TABLE 9. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Mustard Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
captan	AL	0.01	ST	1	Seedling diseases	100	847	8.47
captan	AZ	0.01	ST	1	Seedling diseases	100	200	2.00
captan	CA	0.01	ST	1	Seedling diseases	100	253	2.53
captan	FL	0.01	ST	1	Seedling diseases	100	400	4.00
captan	GA	0.01	ST	1	Seedling diseases	100	3,549	35.49
captan	MD	0.01	ST	1	Seedling diseases	100	200	2.00
captan	NJ	0.01	ST	1	Seedling diseases	100	500	5.00
captan (T)	NY	0.01	ST	1	Seedling diseases	100	75	0.75
captan	OH	0.01	ST	1	Seedling diseases	100	235	2.35
captan	OK	0.01	ST	1	Seedling diseases	100	350	3.50
captan	PA	0.01	ST	1	Seedling diseases	100	100	1.00
captan	SC	0.01	ST	1	Seedling diseases	100	300	3.00
captan	TX	0.01	ST	1	Seedling diseases	50	150	1.50
					U.S. Totals (of states reporting) →			71.59
copper	AL	1.0	F	2	Anthracnose, downy mildew, Alternaria & Cercospora leaf spots	10	85	169
copper (S)	FL	0.5	F	2	Downy mildew, Alternaria leaf spots	10	40	40
copper	GA	1.0	F	5	Downy mildew, Alternaria & Cercospora leaf spots	98	3,478	17,390
copper	MD	1.0	F	2	Downy mildew	10	20	40
copper	NJ	1.0	F	2	Downy mildew, Anthracnose, Alternaria leaf spots	5	25	50

TABLE 9. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Mustard Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	NY	1.0	F	2.5	Downy mildew, Alternaria leaf spots	66	50	124
copper (S)	OH	0.5	F	3	Downy mildew	100	235	353
copper (S)	OK	0.5	F	2	Anthracnose, Alternaria & Cercospora leaf spots, black rot	10	35	35
copper	SC	1.0	F	2	Alternaria, Cercospora & Cercosporella leaf spots	40	120	240
copper (S)	TN	0.5	F	1.5	Downy mildew, Alternaria, Cercospora & Cercosporella leaf spots, Anthracnose	10	100	75
copper	TX	1.0	F	4	Alternaria & Cercospora leaf spots, black rot, downy mildew, bacterial soft rot	100	300	1,200
copper	VA	1.0	F	2	Downy mildew, powdery mildew, leaf spots	20	60	120
					U.S. Totals (of states reporting) →			19,836
fosetyl-Al	AZ	1.6	F	2	Downy mildew	5	10	32
fosetyl-Al	CA	2.4	F	2	Downy mildew	20	51	243
fosetyl-Al	GA	1.6	F	1	Downy mildew	2	71	114
fosetyl-Al	MD	1.6	F	2	Downy mildew	10	20	64
fosetyl-Al	NJ	1.6	F	2	Downy mildew	5	25	80
fosetyl-Al	OH	1.6	F	2	Downy mildew	50	118	376
					U.S. Totals (of states reporting) →			909
sulfur (C)	FL	3.13	F	2	Downy mildew, Alternaria leaf spot	10	40	250
sulfur (C)	OH	3.13	F	3	Downy mildew	100	235	2,207
sulfur (C)	OK	3.13	F	2	Alternaria & Cercospora leaf spots, Anthracnose, black rot	10	35	219
sulfur	SC	4.0	F	2	Powdery mildew	10	30	240

TABLE 9. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Mustard Greens 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
sulfur (C)	TN	3.13	F	1.5	Downy mildew, Alternaria, Cercospora & Cercosporella leaf spots, Anthracnose	10	100	470
					U.S. Totals (of states reporting) →			3,386
thiram	NC	0.01	ST	1	Seedling diseases	90	1,080	10.8
thiram (0)	NY	0.01	ST	1	Seedling diseases	50	38	0.4
thiram	TX	0.01	ST	1	Seedling diseases	50	150	1.5
thiram	VA	0.01	ST	1	Seedling diseases	100	300	3.0
					U.S. Totals (of states reporting) →			15.7
MUSTARD GREENS SEED PRODUCTION								
benomyl	WA	1.0	F	1	White mold, Alternaria leaf spot	100	300	300
captan	WA	0.01	ST	1	Seedling diseases	100	300	3
chlorothalonil	WA	1.13	F	1	Downy mildew, Alternaria leaf spot	100	300	339
metalaxyl	WA	0.25	F	1	Downy mildew	50	150	38

[1] Used in combination with: (C) = copper, (O) = captan, (S) = sulfur, and (T) = thiram, each of which should be consulted for use rates, target pests and total usage of the combination chemical.

[2] Fungicide timing: F = foliar, PP = preplant, ST = seed treatment.

TABLE 10. Impact of the Loss of Individual Fungicides on the Production of Mustard Greens
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
captan	ST	AL	thiram (100)	100	847	0	0
captan	ST	AZ	thiram (100)	100	200	0	0
captan	ST	CA	thiram (100)	100	253	0	0
captan	ST	FL	thiram (100)	100	400	0	0
captan	ST	GA	thiram (100)	100	3,549	0	0
captan	ST	MD	thiram (100)	100	200	0	0
captan	ST	NJ	thiram (100)	100	500	0	0
captan	ST	NY	thiram (50)	100	75	0	0
captan	ST	OH	thiram (100)	100	235	0	0
captan	ST	OK	thiram (100)	100	350	0	0
captan	ST	PA	thiram (100)	100	100	0	0
captan	ST	SC	thiram (100)	100	300	0	0
captan	ST	TX	thiram (50)	50	150	0	0
			U.S. Totals (of states reporting) →	**73**	**7,159**	**0**	**0**
copper	F	AL	None	10	85	- 20	- 177,870
copper	F	GA	fosetyl-Al (23)	98	3,478	- 30	- 12,260,021
copper	F	MD	fosetyl-Al (10)	10	20	0	0
copper	F	NJ	fosetyl-Al (2.5)	5	25	- 5	- 13,125
copper	F	NY	None	66	50	- 20	- 178,200
copper	F	SC	sulfur (2)	40	120	- 10	- 98,400

TABLE 10. Impact of the Loss of Individual Fungicides on the Production of Mustard Greens 1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper	F	TX	fosetyl-Al (5), early harvest (95)	100	300	- 50	- 2,700,000
copper	F	VA	fosetyl-Al (5)	20	60	- 5	-36,000
U.S. Totals (of states reporting) →				**42.2**	**4,137**	**- 13.4**	**- 15,463,616**
copper + sulfur	F	FL	None	10	40	- 10	- 72,000
copper + sulfur	F	OH	fosetyl-Al (100)	100	235	0	0
copper + sulfur	F	OK	None	10	35	- 5	- 28,000
copper + sulfur	F	TN	None	10	100	- 4	- 28,000
U.S. Totals (of states reporting) →				**4.2**	**410**	**- 0.1**	**-128,000**
fosetyl-Al	F	AZ	None	5	10	- 5	- 5,500
fosetyl-Al	F	CA	None	20	51	- 15	- 151,800
fosetyl-Al	F	GA	copper (2)	2	71	- 5	- 41,701
fosetyl-Al	F	MD	copper (5)	10	20	- 15	- 24,000
fosetyl-Al	F	NJ	copper (2)	5	25	- 5	- 13,125
fosetyl-Al	F	OH	copper + sulfur (50)	50	118	- 5	- 94,294
U.S. Totals (of states reporting) →				**3**	**294**	**- 0.3**	**- 330,420**
sulfur	F	SC	None	10	30	- 5	- 12,300
U.S. Totals (of states reporting) →				**0.3**	**30**	**- 0.01**	**- 12,300**
thiram	ST	NC	captan (90)	90	1,080	- 12.5	- 1,485,000
thiram	ST	NY	None (captan already used)	50	38	0	0
thiram	ST	TX	captan (50)	50	150	0	0

TABLE 10. Impact of the Loss of Individual Fungicides on the Production of Mustard Greens
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
thiram	ST	VA	captan (100)	100	300	0	0
			U.S. Totals (of states reporting) →	16	1,568	- 1.3	- 1,485,000
MUSTARD GREENS SEED PRODUCTION							
benomyl	F	WA	None	100	300	- 30	- 135,000 lb seed
captan	ST	WA	thiram (100)	100	300	0	0 lb seed
chlorothalonil	F	WA	metalaxyl (75)	100	300	- 10	- 45,000 lb seed
metalaxyl	F	WA	chlorothalonil (50)	50	150	- 20	- 45,000 lb seed

[1] Fungicide application timing: F = foliar, PP = preplant, ST = seed treatment

[2] Alternatives are other fungicides or nonpesticide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[3] Yield impacts are plus (+) or minus (-) and represent the percent yield change (up to maximum of 100%) on the acreage presently treated with the "lost" fungicide. U.S. totals are based on the 1992 planted acreage in each reporting state. Yield figures (for greens) for Washington state are not included because crop production there is only for seed production.

TABLE 11. Impact of the Loss of Fungicide Groups on the Production of Mustard Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Foliar fungicides	AL	Early harvest (3), excess. trimming (7)	10	85	- 20	- 177,870
Foliar fungicides	AZ	None	5	10	- 5	- 5,500
Foliar fungicides	CA	None	20	51	- 15	- 151,800
Foliar fungicides	FL	None	10	40	- 10	- 72,000
Foliar fungicides	GA	None	100	3,549	- 35	- 14,595,262
Foliar fungicides	MD	None	20	40	- 15	- 48,000
Foliar fungicides	NJ	None	10	50	- 10	- 52,500
Foliar fungicides	NY	None	66	50	- 20	- 178,200
Foliar fungicides	OH	None	100	235	- 15	- 565,763
Foliar fungicides	OK	Early harvest (5), excess. trimming (5)	10	35	- 5	- 28,000
Foliar fungicides	SC	None	50	150	- 15	- 184,500
Foliar fungicides	TN	None	10	100	- 5	- 35,000
Foliar fungicides	TX	None	100	300	- 50	- 2,700,000
Foliar fungicides	VA	None	20	60	- 5	- 36,000
		U.S. Totals (of states reporting) →	**48.5**	**4,754**	**- 16.3**	**- 18,830,395**
Seed-treatment fungicides	AL	None	100	847	- 20	- 1,778,700
Seed-treatment fungicides	AZ	None	100	200	- 7	- 154,000
Seed-treatment fungicides	CA	None	100	253	0	0
Seed-treatment fungicides	FL	None	100	400	- 7	- 504,000
Seed-treatment fungicides	GA	None	100	3,549	- 10	- 4,170,075

TABLE 11. Impact of the Loss of Fungicide Groups on the Production of Mustard Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Seed-treatment fungicides	MD	None	100	200	- 12.5	- 200,000
Seed-treatment fungicides	NC	None	90	1,080	- 12.5	- 1,485,000
Seed-treatment fungicides	NJ	None	100	500	- 10	- 525,000
Seed-treatment fungicides	NY	None	100	75	- 25	- 337,500
Seed-treatment fungicides	OH	None	100	235	- 10	- 377,175
Seed-treatment fungicides	OK	None	100	350	- 10	- 560,000
Seed-treatment fungicides	PA	None	100	100	- 10	- 100,000
Seed-treatment fungicides	SC	None	100	300	- 20	- 492,000
Seed-treatment fungicides	TX	None	100	300	- 1	- 54,000
Seed-treatment fungicides	VA	None	100	300	- 5	- 180,000
		U.S. Totals (of states reporting) →	**88.6**	**8,689**	**- 9.5**	**- 10,917,450**
MUSTARD GREENS SEED PRODUCTION						
Foliar fungicides	WA	None	100	300	- 50	- 225,000 lb seed
Seed-treatment fungicides	WA	None	100	300	- 5	- 22,500 lb seed

[1] Alternatives are other fungicides, fungicide groups, or nonfungicide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide group that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide group, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[2] Yield impacts are plus (+) and minus (-) and represent the percent yield change (up to a maximum of 100%) on the acreage presently treated with the "lost" fungicide group. U.S. totals are based on 1992 planted acreage in each reporting state.

TABLE 12. Nonpesticide Control Practices for Pests on Mustard Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Acreage Where Practiced	Acreage where Practiced
Rotation	AL	Seedling diseases	100	847
Rotation	AZ	Seedling diseases	100	200
Rotation	CA	Seedling diseases	100	253
Rotation	FL	Seedling diseases	10	40
Rotation	GA	Seedling diseases	100	3,549
Rotation	MD	Seedling diseases	100	200
Rotation	NC	Seedling diseases	100	1,200
Rotation	NJ	Seedling diseases	100	500
Rotation	NY	Seedling diseases	100	75
Rotation	OH	Seedling diseases	100	235
Rotation	OK	Seedling diseases	90	315
Rotation	PA	Seedling diseases	40	40
Rotation	SC	Seedling diseases, leaf spots	100	300
Rotation	TN	Seedling diseases	20	200
Rotation	TX	Seedling diseases	100	300
Rotation	VA	Seedling diseases	100	300
		U.S. Totals (of states reporting) →	**87.2**	**8,554**
		MUSTARD GREENS SEED PRODUCTION		
Rotation	WA	Seedling diseases, white mold	100	300

[1] Rotation = in the preceding year, the percentage of the current crop acreage (1992) that had an alternate crop on it.

TABLE 13. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Turnip Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
benomyl	AL	0.25	F	2	Anthracnose, Alternaria & Cercospora leaf spot	45	1,039	520
benomyl	GA	0.25	F	2	Anthracnose, Alternaria & Cercospora leaf spot	90	8,144	4,072
benomyl	TN	0.25	F	1.5	Anthracnose, Alternaria & Cercospora leaf spot	10	150	56
					U.S. Totals (of states reporting) →			**4,648**
captan	AL	0.03	ST	1	Seedling diseases	100	2,308	69.2
captan	AZ	0.03	ST	1	Seedling diseases	100	100	3.0
captan	CA	0.03	ST	1	Seedling diseases	100	183	5.5
captan	FL	0.03	ST	1	Seedling diseases	100	400	12.0
captan	GA	0.03	ST	1	Seedling diseases	100	9,049	271.5
captan	MD	0.03	ST	1	Seedling diseases	100	186	5.6
captan	NJ	0.03	ST	1	Seedling diseases	100	250	7.5
captan	NY	0.03	ST	1	Seedling diseases	100	75	2.3
captan	OH	0.03	ST	1	Seedling diseases	100	275	8.3
captan	OK	0.03	ST	1	Seedling diseases	100	900	27.0
captan	PA	0.03	ST	1	Seedling diseases	100	70	2.1
captan	SC	0.03	ST	1	Seedling diseases	90	585	17.6
captan	TX	0.03	ST	1	Seedling diseases	50	500	15.0
captan	VA	0.03	ST	1	Seedling diseases	100	400	12.0
					U.S. Totals (of states reporting) →			**458.6**

TABLE 13. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Turnip Greens 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	AL	1.0	F	2	Anthracnose, Alternaria & Cercospora leaf spots, downy mildew, black rot	5	115	231
copper (S)	FL	0.5	F	1	Alternaria & Cercospora leaf spots, downy mildew	5	20	10
copper	GA	1.0	F	5	Anthracnose, Alternaria & Cercospora leaf spots, downy mildew	100	9,049	45,245
copper	MD	1.0	F	2	Downy mildew, Alternaria leaf spot	10	19	38
copper	NJ	1.0	F	2	Downy mildew, Anthracnose	5	13	25
copper	NY	1.0	F	2.5	Downy mildew, Alternaria leaf spots	66	50	124
copper (S)	OH	0.5	F	3	Downy mildew, leaf spots	100	275	413
copper (S)	OK	0.5	F	2	Downy mildew, leaf spots, black rot	25	225	225
copper	SC	1.0	F	2	Alternaria, Cercospora & Cercosporella leaf spots	60	390	780
copper (S)	TN	0.5	F	1.5	Anthracnose, leaf spots, downy mildew	10	150	113
copper	TX	1.0	F	3	Black rot, downy mildew, leaf spots, bacterial soft rot	95	950	2,850
copper	VA	1.0	F	2	Black rot, leaf spots, powdery mildew	20	80	160
					U.S. Totals (of states reporting) →			**50,214**
metalaxyl	AL	1.0	PP	1	Seedling diseases	5	115	115
metalaxyl	FL	1.0	PP	1	Pythium seedling diseases, root rot	10	40	40
metalaxyl	MD	1.0	PP	1	Downy mildew, seedling diseases	2	4	4
metalaxyl	NJ	1.0	PP	1	Seedling diseases	10	25	25
metalaxyl	PA	1.0	PP	1	Pythium seedling diseases, root rot	25	18	18

TABLE 13. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Turnip Greens 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
metalaxyl	SC	1.0	PP	1	Seedling diseases, early season downy mildew	5	33	33
					U.S. Totals (of states reporting) →			**235**
sulfur	FL	4.5	F	2	Alternaria & Cercospora leaf spots	15	60	540
sulfur (C)	FL	3.13	F	1	Alternaria & Cercospora leaf spots, downy mildew	5	20	63
sulfur (C)	OH	3.13	F	3	Downy mildew	100	275	2,582
sulfur (C)	OK	3.13	F	2	Downy mildew, leaf spots	25	225	1,409
sulfur	SC	4.0	F	2	Powdery mildew	5	33	260
sulfur (C)	TN	3.13	F	1.5	Anthracnose, leaf spots, downy mildew	10	150	704
					U.S. Totals (of states reporting) →			**5,558**
thiram	NC	0.03	ST	1	Seedling diseases	90	1,170	35.1
thiram	NY	0.01	ST	1	Seedling diseases	50	38	0.4
thiram	TX	0.03	ST	1	Seedling diseases	50	500	15.0
					U.S. Totals (of states reporting) →			**50.5**
					TURNIP GREENS SEED PRODUCTION			
benomyl	WA	1.00	F	1	White mold, anthracnose, Alternaria & Cercospora leaf spot	20	400	400
chlorothalonil (R)	WA	1.44	F	1	Downy mildew, Alternaria leaf spot	20	400	576
iprodione	WA	1.00	F	1	White mold, Alternaria leaf spot	20	400	400
metalaxyl (D)	WA	0.18	F	1	Downy mildew	20	400	72
metalaxyl (T)	WA	0.006	ST	1	Seedling diseases	80	1,600	10

TABLE 13. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Turnip Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli- cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
thiram (R)	WA	0.03	ST	1	Damping-off	80	1,600	48

[1] Used in combination with: (C) = copper, (D) = chlorothalonil, (R) = metalaxyl, (S) = sulfur, (T) = thiram, each of which should be consulted for use rates, target pests and total usage of the combination chemical.
[2] Fungicide timing: F = foliar, PP = preplant, ST = seed treatment.

TABLE 14. Impact of the Loss of Individual Fungicides on the Production of Turnip Greens
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
benomyl	F	AL	copper (5)	45	1,039	- 40	- 4,569,840
benomyl	F	GA	copper (90)	90	8,144	- 35	- 33,492,611
benomyl	F	TN	copper (10)	10	150	- 3	- 40,500
			U.S. Totals (of states reporting) →	**50.1**	**9,333**	**- 16.3**	**- 38,102,951**
captan	ST	AL	thiram (100)	100	2,308	0	0
captan	ST	AZ	thiram (100)	100	100	0	0
captan	ST	CA	thiram (100)	100	183	0	0
captan	ST	FL	thiram (100)	100	400	0	0
captan	ST	GA	thiram (100)	100	9,049	0	0
captan	ST	MD	thiram (100)	100	186	0	0
captan	ST	NJ	thiram (100)	100	250	0	0
captan	ST	NY	thiram (100)	100	75	0	0
captan	ST	OH	thiram (100)	100	275	0	0
captan	ST	OK	thiram (100)	100	900	0	0
captan	ST	PA	thiram (100)	100	70	0	0
captan	ST	SC	thiram (90)	90	585	0	0
captan	ST	TX	thiram (50)	50	500	0	0
captan	ST	VA	thiram (100)	100	400	0	0
			U.S. Totals (of states reporting) →	**82**	**15,281**	**0**	**0**
copper	F	AL	None	5	115	- 25	- 317,350

TABLE 14. Impact of the Loss of Individual Fungicides on the Production of Turnip Greens
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper	F	GA	benomyl (10)	100	9,049	- 25	- 26,581,438
copper	F	MD	None	10	19	- 12.5	- 17,438
copper	F	NJ	None	5	13	- 5	- 6,875
copper	F	NY	None	66	50	- 20	- 178,200
copper	F	SC	None	60	390	- 50	- 1,452,750
copper	F	TX	None	95	950	- 40	- 7,980,000
copper	F	VA	None	20	80	- 5	- 36,000
			U.S. Totals (of states reporting) →	**57.2**	**10,665**	**- 15.7**	**- 36,570,050**
copper + sulfur	F	FL	None	5	20	- 2	- 7,200
copper + sulfur	F	OH	None	100	275	- 15	- 787,050
copper + sulfur	F	OK	None	25	225	- 10	- 360,000
copper + sulfur	F	TN	benomyl (10)	10	150	- 2	- 27,000
			U.S. Totals (of states reporting) →	**3.6**	**670**	**- 0.5**	**- 1,181,250**
metalaxyl	PP	AL	None	5	115	- 5	- 63,470
metalaxyl	PP	FL	None	10	40	- 5	- 36,000
metalaxyl	PP	MD	None	2	4	- 5	- 1,395
metalaxyl	PP	NJ	None	10	25	- 5	- 13,750
metalaxyl	PP	PA	None	25	18	- 15	- 26,250
metalaxyl	PP	SC	None	5	33	- 5	- 12,106
			U.S. Totals (of states reporting) →	**1.3**	**235**	**- 0.1**	**- 152,971**

TABLE 14. Impact of the Loss of Individual Fungicides on the Production of Turnip Greens
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
sulfur	F	FL	None	15	60	- 5	- 54,000
sulfur	F	SC	None	5	33	0	0
			U.S. Totals (of states reporting) →	**0.5**	**93**	**- 0.02**	**- 54,000**
thiram	ST	NC	captan (90)	90	1,170	- 12.5	- 2,340,000
thiram	ST	NY	None	50	38	0	0
thiram	ST	TX	captan (50)	50	500	0	0
			U.S. Totals (of states reporting) →	**9.2**	**1,708**	**- 1.0**	**- 2,340,000**
TURNIP GREENS SEED PRODUCTION							
benomyl	F	WA	iprodione (20)	20	400	- 5	- 30,000 lb seed
chlorothalonil + metalaxyl	F	WA	None	20	400	- 20	- 120,000 lb seed
iprodione	F	WA	benomyl (10),chlorothalonil (10)	20	400	- 5	- 30,000 lb seed
metalaxyl	ST	WA	None	80	1,600	- 10	- 240,000 lb seed
thiram	ST	WA	captan (80)	80	1,600	0	0 lb seed

1 Fungicide application timing: F = foliar, PP = preplant, ST = seed treatment

2 Alternatives are other fungicides or nonpesticide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide, unless there is nontreatment or overlap treatment on the formerly treated acreage.

3 Yield impacts are plus (+) or minus (-) and represent the percent yield change (up to maximum of 100%) on the acreage presently treated with the "lost" fungicide. U.S. totals are based on the 1992 planted acreage in each reporting state. Yield figures (for greens) for Washington state are not included because crop production there is only for seed production.

TABLE 15. Impact of the Loss of Fungicide Groups on the Production of Turnip Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Foliar fungicides	AL	Premature harvest (32.5), trimming (17.5)	50	1,154	- 45	- 5,712,300
Foliar fungicides	FL	None	20	80	- 8.5	- 122,400
Foliar fungicides	GA	None	100	9,049	- 85	- 90,376,888
Foliar fungicides	MD	None	20	37	- 17.5	- 48,825
Foliar fungicides	NJ	None	5	13	- 10	- 13,750
Foliar fungicides	NY	None	66	50	- 20	- 178,200
Foliar fungicides	OH	None	100	275	- 15	- 787,050
Foliar fungicides	OK	Early harvest (25)	25	225	- 10	- 360,000
Foliar fungicides	SC	Early harvest (49)	65	423	- 50	- 1,573,813
Foliar fungicides	TN	None	20	300	- 10	- 270,000
Foliar fungicides	TX	None	95	950	- 40	- 7,980,000
Foliar fungicides	VA	metalaxyl - PP (10)	20	80	- 10	- 72,000
		U.S. Totals (of states reporting) →	**67.8**	**12,635**	**- 46.1**	**- 107,495,225**
Preplant fungicides	AL	None	5	115	- 5	- 63,470
Preplant fungicides	FL	None	10	40	- 5	- 36,000
Preplant fungicides	MD	None	2	4	- 5	- 1,395
Preplant fungicides	NJ	None	10	25	- 5	- 13,750
Preplant fungicides	PA	None	25	18	- 15	- 26,250

TABLE 15. Impact of the Loss of Fungicide Groups on the Production of Turnip Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Preplant fungicides	SC	None	5	33	- 5	- 12,106
		U.S. Totals (of states reporting) →	**1.3**	**234**	**- 0.07**	**- 152,971**
Seed-treatment fungicides	AL	None	100	2,308	- 20	- 5,077,600
Seed-treatment fungicides	AZ	None	100	100	- 7	- 78,750
Seed-treatment fungicides	CA	None	100	183	0	0
Seed-treatment fungicides	FL	None	100	400	- 7	- 504,000
Seed-treatment fungicides	GA	None	100	9,049	- 10	- 10,632,575
Seed-treatment fungicides	MD	None	100	186	-12.5	- 174,375
Seed-treatment fungicides	NC	None	90	1,170	- 12.5	- 2,340,000
Seed-treatment fungicides	NJ	None	100	250	- 7	- 192,500
Seed-treatment fungicides	NY	None	100	75	- 15	- 202,500
Seed-treatment fungicides	OH	None	100	275	- 7	- 367,290
Seed-treatment fungicides	OK	None	100	900	- 12	- 1,728,000
Seed-treatment fungicides	PA	None	100	70	- 7	- 49,000
Seed-treatment fungicides	SC	None	90	585	- 20	- 871,650
Seed-treatment fungicides	TX	None	100	1,000	- 1	- 210,000
Seed-treatment fungicides	VA	None	100	400	- 5	- 180,000
		U.S. Totals (of states reporting) →	**90.9**	**16,951**	**- 9.7**	**- 22,608,240**

TABLE 15. Impact of the Loss of Fungicide Groups on the Production of Turnip Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
TURNIP GREENS SEED PRODUCTION						
Foliar fungicides	WA	None	60	1,200	- 25	- 450,000 lb seed
Seed-treatment fungicides	WA	None	80	1,600	- 12	- 288,000 lb seed

[1] Alternatives are other fungicides, fungicide groups, or nonfungicide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide group that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide group, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[2] Yield impacts are plus (+) and minus (-) and represent the percent yield change (up to a maximum of 100%) on the acreage presently treated with the "lost" fungicide group. U.S. totals are based on 1992 planted acreage in each reporting state.

TABLE 16. Nonpesticide Control Practices for Pests on Turnip Greens
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Acreage Where Practiced	Acreage where Practiced
Rotation	AL	Seedling diseases	90	2,077
Rotation	AZ	Seedling diseases	100	100
Rotation	CA	Seedling diseases	100	183
Rotation	FL	Seedling diseases	80	320
Rotation	GA	Seedling diseases	100	9,049
Rotation	MD	Seedling diseases	100	186
Rotation	NC	Seedling diseases	100	1,300
Rotation	NJ	Seedling diseases	100	250
Rotation	NY	Seedling diseases	100	75
Rotation	OH	Seedling diseases	100	275
Rotation	OK	Seedling diseases, black rot, downy mildew, leaf spots	80	720
Rotation	PA	Seedling diseases	40	28
Rotation	SC	Seedling diseases	100	650
Rotation	TN	Seedling diseases	20	300
Rotation	TX	Seedling diseases, black rot, downy mildew	100	1,000
Rotation	VA	Seedling diseases	100	400
		U.S. Totals (of states reporting) →	**90.7**	**16,913**
		TURNIP GREENS SEED PRODUCTION		
Rotation	WA	Seedling diseases, white rot	100	2,000

[1] Rotation = in the preceding year, the percentage of the current crop acreage (1992) that had an alternate crop on it.

TABLE 17. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Lettuce
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli- cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	CA	1.0	F	1	Downy mildew--late season use	9	17,550	17,550
copper	NY	1.0	F	2	Downy mildew, Septoria leaf spot	5	136	272
copper	OH	2.0	F	2	Bacterial spot	20	246	984
copper	TX	1.0	F	2	Septoria leaf spot, downy mildew	10	75	150
					U.S. Totals (of states reporting) →			**18,956**
fosetyl-Al	AZ	1.6	F	2	Downy mildew	5	2,775	8,880
fosetyl-Al	CA	2.4	F	2.5	Downy mildew	26	50,700	304,200
fosetyl-Al	FL	2.8	F	1.5	Downy mildew	35	3,850	16,170
fosetyl-Al	NJ	1.6	F	2	Downy mildew	5	126	404
fosetyl-Al	TX	1.6	F	2	Downy mildew	40	300	960
					U.S. Totals (of states reporting) →			**330,614**
iprodione	AZ	1.0	F	3	Drop	15	8,325	24,975
iprodione	CA	1.0	F	1.5	Drop	60	117,000	175,500
iprodione	FL	1.0	F	2	Bottom rot	27.5	3,025	6,050
iprodione	NJ	1.0	F	3	Drop, bottom rot	60	1,513	4,540
iprodione	NY	0.75	F	2.4	Drop, gray mold, bottom rot	100	2,720	4,937
iprodione	OH	1.0	F	3	Drop, bottom rot	30	369	1,107
iprodione	WA	1.0	F	2	Drop, bottom rot, seedling diseases	50	730	1,460
					U.S. Totals (of states reporting) →			**218,568**
maneb	AZ	1.6	F	2	Downy mildew	30	16,650	53,280

TABLE 17. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Lettuce 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
maneb	CA	1.6	F	2.5	Downy mildew	45	87,750	351,000
maneb	FL	1.6	F	5.5	Downy mildew	90	9,900	87,120
maneb	NJ	1.6	F	2	Downy mildew, Septoria leaf spot	10	252	807
maneb	NY	1.2	F	3	Downy mildew, Septoria leaf spot	58	1,578	5,679
maneb (R)	TX	1.6	F	2	Septoria leaf spot, downy mildew	40	300	960
maneb	TX	1.6	F	2	Septoria leaf spot, downy mildew	10	75	240
					U.S. Totals (of states reporting) →			**499,086**
metalaxyl	AZ	1.0	PP	1	Seedling diseases, downy mildew	15	8,325	8,325
metalaxyl	CA	0.75	PP	1	Downy mildew, seedling diseases	20	39,000	29,250
metalaxyl	FL	1.0	PP	1	Seedling diseases, early season downy mildew	2	220	220
metalaxyl	NJ	1.0	PP	1	Seedling diseases, downy mildew	25	631	631
metalaxyl	NY	1.0	PP	1	Seedling diseases, downy mildew	58	1,578	1,578
metalaxyl (M)	TX	0.28	F	2	Downy mildew	40	300	168
					U.S. Totals (of states reporting) →			**40,171**
thiram	FL	0.0005	ST	1	Seedling diseases	100	11,000	5.5
thiram	NJ	0.0005	ST	1	Seedling diseases	100	2,522	1.3
thiram	NY	0.0005	ST	1	Seedling diseases	75	2,040	1.0
thiram	OH	0.0005	ST	1	Seedling diseases	50	615	0.3
thiram	WA	0.0005	ST	1	Seedling diseases	100	1,460	0.7
					U.S. Totals (of states reporting) →			**8.8**

**TABLE 17. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Lettuce
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State**

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
vinclozolin	AZ	1.0	F	3	Drop	15	8,325	24,975
vinclozolin	CA	0.75	F	1.5	Drop	40	78,000	87,750
vinclozolin	FL	1.0	F	1	Drop	1	110	110
vinclozolin	NJ	0.75	F	3	Drop	40	1,009	2,270
vinclozolin	NY	0.5	F	1	Drop, gray mold	65	1,768	884
vinclozolin	OH	0.75	F	3	Drop	8	98	221
vinclozolin	WA	1.0	F	2	Drop	50	730	1,460
					U.S. Totals (of states reporting) →			**117,670**

[1] Used in combination with: (M) = maneb and (R) = metalaxyl, each of which should be consulted for use rates, target pests and total usage of the combination chemical.

[2] Fungicide timing: F = foliar, PP = preplant, ST = seed treatment

TABLE 18. Impact of the Loss of Individual Fungicides on the Production of Lettuce
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper	F	CA	None	9	17,550	0	0
copper	F	NY	None	5	136	0	0
copper	F	OH	None	20	246	- 2	- 70,258
copper	F	TX	maneb (10)	10	75	0	0
			U.S. Totals (of states reporting) →	**6.7**	**18,007**	**- 0.0008**	**- 70,258**
fosetyl-Al	F	AZ	maneb (5)	5	2,775	0	0
fosetyl-Al	F	CA	maneb (26)	26	50,700	- 1	- 17,238,000
fosetyl-Al	F	FL	metalaxyl (5), maneb (10), copper (10)	35	3,850	0	0
fosetyl-Al	F	NJ	maneb (5)	5	126	0	0
fosetyl-Al	F	TX	maneb (10), metalaxyl + maneb (30)	40	300	0	0
			U.S. Totals (of states reporting) →	**21.5**	**57,751**	**- 0.2**	**- 17,238,000**
iprodione	F	AZ	vinclozolin (15)	15	8,325	- 5	- 10,510,313
iprodione	F	CA	vinclozolin (60)	60	117,000	- 5	- 198,900,000
iprodione	F	FL	vinclozolin (27.5)	27.5	3,025	- 15	- 8,439,750
iprodione	F	NJ	vinclozolin (10)	60	1,513	- 25	- 5,296,200
iprodione	F	NY	None	100	2,720	- 50	- 26,520,000
iprodione	F	OH	vinclozolin (30)	30	369	- 10	- 526,932
iprodione	F	WA	vinclozolin (50)	50	730	- 5	- 996,450
			U.S. Totals (of states reporting) →	**49.3**	**133,682**	**- 3.0**	**- 251,189,645**

TABLE 18. Impact of the Loss of Individual Fungicides on the Production of Lettuce
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
maneb	F	AZ	copper (3)	30	16,650	- 7	- 29,428,875
maneb	F	CA	fosetyl-Al + copper (45)	45	87,750	- 13	- 372,937,500
maneb	F	FL	metalaxyl (5), fosetyl-Al (50), copper (10)	90	9,900	- 70	- 128,898,000
maneb	F	NJ	copper (2)	10	252	- 5	- 176,540
maneb	F	NY	None	58	1,578	- 30	- 9,228,960
maneb	F	TX	metalaxyl (4)	10	75	- 3	- 22,500
			U.S. Totals (of states reporting) →	**42.8**	**116,205**	**- 6.4**	**- 540,692,375**
maneb + metalaxyl	F	TX	maneb (5), fosetyl-Al (30)	40	300	- 30	- 900,000
			U.S. Totals (of states reporting) →	**0.3**	**300**	**- 0.01**	**- 900,000**
metalaxyl	PP	AZ	None	15	8,325	- 5	- 10,510,313
metalaxyl	PP	CA	None	20	39,000	0	0
metalaxyl	PP	FL	None	2	220	- 1	- 40,920
metalaxyl	PP	NJ	None	25	631	- 5	- 441,350
metalaxyl	PP	NY	None	58	1,578	- 10	- 3,076,320
			U.S. Totals (of states reporting) →	**18.3**	**49,754**	**- 0.2**	**- 14,068,903**
thiram	ST	FL	None	100	11,000	- 15	- 30,690,000
thiram	ST	NJ	None	100	2,522	- 10	- 3,530,800
thiram	ST	NY	None	75	2,040	- 15	- 5,967,000
thiram	ST	OH	None	50	615	- 5	- 439,110

TABLE 18. Impact of the Loss of Individual Fungicides on the Production of Lettuce
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide	Timing[1]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[2]	% of acreage currently treated	Acreage currently treated	% Yield impact[3] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
thiram	ST	WA	None	100	1,460	- 7	- 2,790,060
			U.S. Totals (of states reporting) →	**6.5**	**17,637**	**- 0.5**	**- 43,416,970**
vinclozolin	F	AZ	iprodione (15)	15	8,325	- 5	- 10,510,313
vinclozolin	F	CA	iprodione (40)	40	78,000	- 3	- 79,560,000
vinclozolin	F	FL	iprodione (1)	1	110	- 5	- 102,300
vinclozolin	F	NJ	iprodione (40)	40	1,009	- 5	- 706,160
vinclozolin	F	NY	iprodione (35 x 3 applications[4]) (65)	65	1,768	- 5	- 1,723,800
vinclozolin	F	OH	iprodione (8)	8	98	- 5	- 70,258
vinclozolin	F	WA	iprodione (50)	50	730	- 5	- 996,450
			U.S. Totals (of states reporting) →	**33.2**	**90,040**	**- 1.1**	**- 93,669,280**

[1] Fungicide application timing: F = foliar, PP = preplant, ST = seed treatment

[2] Alternatives are other fungicides or nonpesticide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[3] Yield impacts are plus (+) or minus (-) and represent the percent yield change (up to maximum of 100%) on the acreage presently treated with the "lost" fungicide. U.S. totals are based on the 1992 planted acreage in each reporting state. Yield figures (for greens) for Washington state are not included because crop production there is only for seed production.

[4] Would use 3 applications instead of 2 applications of vinclozolin.

TABLE 19. Impact of the Loss of Fungicide Groups on the Production of Lettuce
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Foliar fungicides	AZ	None	65	36,075	- 45	- 409,902,188
Foliar fungicides	CA	None	100	195,000	- 23	- 1,524,900,000
Foliar fungicides	FL	None	100	11,000	- 70	- 143,220,000
Foliar fungicides	NJ	None	100	2,522	- 50	- 17,654,000
Foliar fungicides	NY	None	100	2,720	- 70	- 37,128,000
Foliar fungicides	OH	None	58	713	- 50	- 5,093,676
Foliar fungicides	TX	None	100	750	- 60	- 4,500,000
Foliar fungicides	WA	None	100	1,460	- 20	- 7,971,600
		U.S. Totals (of states reporting) →	**92.7**	**250,240**	**- 25.6**	**- 2,150,369,463**
Preplant fungicides	AZ	None	15	8,325	- 5	- 10,510,313
Preplant fungicides	CA	None	20	39,000	0	0
Preplant fungicides	FL	None	2	220	- 1	- 40,920
Preplant fungicides	NJ	None	25	631	- 5	- 441,350
Preplant fungicides	NY	None	58	1,578	- 10	- 3,076,320
		U.S. Totals (of states reporting) →	**18.3**	**49,754**	**- 0.2**	**- 14,068,903**
Seed-treatment fungicides	FL	None	100	11,000	- 15	- 30,690,000
Seed-treatment fungicides	NJ	None	100	2,522	- 10	- 3,530,800
Seed-treatment fungicides	NY	None	75	2,040	- 15	- 5,967,000

TABLE 19. Impact of the Loss of Fungicide Groups on the Production of Lettuce
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Seed-treatment fungicides	OH	None	50	615	- 5	- 439,110
Seed-treatment fungicides	WA	None	100	1,460	- 7	- 2,790,060
		U.S. Totals (of states reporting) →	**6.5**	**17,637**	**- 0.52**	**- 43,416,970**

[1] Alternatives are other fungicides, fungicide groups, or nonfungicide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide group that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide group, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[2] Yield impacts are plus (+) and minus (-) and represent the percent yield change (up to a maximum of 100%) on the acreage presently treated with the "lost" fungicide group. U.S. totals are based on 1992 planted acreage in each reporting state.

TABLE 20. Nonpesticide Control Practices for Pests on Lettuce
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Acreage Where Practiced	Acreage where Practiced
Rotation	AZ	Seedling diseases, drop, bottom rot	100	55,500
Rotation	CA	Seedling diseases, drop	100	195,000
Rotation	FL	Seedling diseases, bottom rot	100	11,000
Rotation	NJ	Seedling diseases, drop, bottom rot	33	832
Rotation	NY	Seedling diseases, drop, bottom rot	33	898
Rotation	OH	Seedling diseases	100	1,230
Rotation	TX	Seedling diseases, drop, bottom rot	100	750
		U.S. Totals (of states reporting) →	**98.2**	**265,210**

[1] Rotation = in the preceding year, the percentage of the current crop acreage (1992) that had an alternate crop on it.

TABLE 21. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Spinach 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
captan	AR	0.03	ST	1	Seedling diseases	100	1,000	30
captan	AZ	0.03	ST	1	Seedling diseases	100	530	16
captan	CA	0.03	ST	1	Seedling diseases	100	10,558	317
captan	DE	0.03	ST	1	Seedling diseases	100	800	24
captan	FL	0.03	ST	1	Seedling diseases	100	300	9
captan	GA	0.03	ST	1	Seedling diseases	100	80	2
captan	MD	0.03	ST	1	Seedling diseases	100	2,700	81
captan (T)	NC	0.03	ST	1	Seedling diseases	90	900	27
captan	NJ	0.03	ST	1	Seedling diseases	100	2,551	77
captan (T)	NY	0.03	ST	1	Seedling diseases	100	1,700	51
captan	OH	0.03	ST	1	Seedling diseases	100	65	2
captan	OK	0.03	ST	1	Seedling diseases	100	3,280	98
captan	SC	0.03	ST	1	Seedling diseases	100	150	5
captan	TX	0.03	ST	1	Seedling diseases	50	6,000	180
captan	VA	0.03	ST	1	Seedling diseases	100	1,200	36
					U.S. Totals (of states reporting) →			**955**
copper	AR	1.0	F	2	White rust	30	300	600
copper (R)	AR	1.5	F	1	White rust, blue mold	50	500	750
copper	AZ	1.0	F	2	Blue mold	10	53	106
copper	DE	1.0	F	2	White rust	50	400	800

TABLE 21. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Spinach 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]		State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	(R)	DE	1.5	F	2	White rust, blue mold	10	80	240
copper		FL	1.0	F	2	White rust, blue mold	10	30	60
copper	(R)	FL	1.5	F	1	White rust, blue mold	10	30	45
copper		GA	1.0	F	2	White rust	85	68	136
copper	(R)	GA	1.5	F	1	White rust, blue mold	75	60	90
copper		MD	1.0	F	2	White rust	40	1,080	2,160
copper	(R)	MD	1.5	F	2	White rust, blue mold	10	270	810
copper		NJ	1.0	F	2	White rust	50	1,276	2,551
copper	(R)	NJ	1.5	F	1	White rust, blue mold	10	255	383
copper		NY	1.0	F	3	White rust, blue mold, Anthracnose, Cladosporium, Cercospora leaf spot	95	1,615	4,845
copper	(R)	NY	1.5	F	1	White rust, blue mold	88	1,496	2,244
copper	(R)	OH	1.5	F	2	White rust, blue mold	85	55	166
copper	(S)	OK	0.5	F	2	White rust, blue mold, Anthracnose	20	656	656
copper	(R)	OK	1.5	F	1	White rust, blue mold, Anthracnose	15	492	738
copper		SC	1.0	F	2	White rust, Cercospora leaf spot, Anthracnose	50	75	150
copper	(R)	SC	1.5	F	1.5	White rust, Cercospora leaf spot, Anthracnose	20	30	68
copper	(S)	TN	0.5	F	1.5	White rust, blue mold, Anthracnose, Cercospora leaf spot	10	200	150
copper		TX	1.0	F	4	White rust, blue mold, Cercospora leaf spot	83	9,960	39,840
copper	(R)	TX	1.5	F	1	White rust, blue mold, Cercospora leaf spot	2	240	360

TABLE 21. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Spinach 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli-cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
copper	VA	1.0	F	2	White rust, Cercospora leaf spot	50	600	1,200
copper (R)	VA	1.5	F	2	White rust, blue mold	50	600	1,800
					U.S. Totals (of states reporting) →			**61,330**
fosetyl-Al	AZ	1.6	F	2	Blue mold	10	53	170
fosetyl-Al	CA	2.4	F	1.5	Blue mold (state label)	45	4,751	17,104
fosetyl-Al	DE	1.6	F	2	White rust, blue mold	10	80	256
fosetyl-Al	FL	1.6	F	1	White rust, blue mold	2	6	10
fosetyl-Al	GA	1.6	F	2	White rust, blue mold	2	2	5
fosetyl-Ai	MD	1.6	F	2	White rust, blue mold	10	270	864
fosetyl-Al	NJ	1.6	F	2	White rust, blue mold	10	255	816
fosetyl-Al	SC	1.6	F	1	White rust, blue mold	5	8	12
					U.S. Totals (of states reporting) →			**19,237**
metalaxyl (C)	AR	0.25	F	1	White rust, blue mold	50	500	125
metalaxyl	AR	1.0	PP	1	Seedling diseases, white rust	100	1,000	1,000
metalaxyl	AZ	1.0	PP	1	Seedling diseases, blue mold	25	133	133
metalaxyl	CA	0.75	PP	1	Seedling diseases, blue mold	70	7,391	5,543
metalaxyl	DE	1.0	PP	1	Blue mold, seedling diseases, white rust	50	400	400
metalaxyl (C)	DE	0.25	F	1	Blue mold, white rust	10	80	20
metalaxyl	FL	1.0	PP	1	Seedling diseases (Pythium spp.)	10	30	30
metalaxyl (C)	FL	0.25	F	1	White rust, blue mold	10	30	8

TABLE 21. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Spinach 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of applications	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
metalaxyl (C)	GA	0.25	F	1	White rust, blue mold	75	60	15
metalaxyl	GA	1.0	PP	1	Seedling diseases, white rust, blue mold	100	80	80
metalaxyl (C)	MD	0.25	F	2	Blue mold, white rust	10	270	135
metalaxyl	MD	1.0	PP	1	Seedling diseases, blue mold, white rust	100	2,700	2,700
metalaxyl (C)	NJ	0.25	F	1	Blue mold, white rust	10	255	64
metalaxyl	NJ	1.0	PP	1	Seedling diseases, white rust, blue mold	100	2,551	2,551
metalaxyl (C)	NY	0.25	F	1	White rust, blue mold	88	1,496	374
metalaxyl	NY	1.0	PP	1	White rust, blue mold, seedling diseases	99	1,683	1,683
metalaxyl	OH	2.0	PP	1	White rust, blue mold, seedling diseases (Pythium spp.)	85	55	111
metalaxyl (C)	OH	0.25	F	2	White rust (fall only), blue mold	85	55	28
metalaxyl	OK	0.5	PP	1	White rust, blue mold, seedling diseases	50	1,640	820
metalaxyl (C)	OK	0.25	F	1	White rust, blue mold	15	492	123
metalaxyl	SC	1.0	PP	1	White rust, blue mold, seedling diseases	100	150	150
metalaxyl (C)	SC	0.25	F	1.5	White rust, blue mold, seedling diseases	20	30	11
metalaxyl (C)	TX	0.25	F	1	White rust, blue mold, Cercospora leaf spot	2	240	60
metalaxyl	TX	0.5	PP	1	Seedling diseases, white rust, blue mold	95	11,400	5,700
metalaxyl	VA	1.0	PP	1	White rust, blue mold, seedling diseases	100	1,200	1,200
metalaxyl (C)	VA	0.25	F	2	White rust, blue mold	50	600	300
					U.S. Totals (of states reporting) →			23,364

TABLE 21. Fungicide Use Patterns, Target Pests, Acreage Treated, and Pounds Fungicides Used on Spinach 1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide-State

Fungicide[1]	State	Treatment rate (lb ai/A)	Timing[2] of treatment	Number of appli- cations	Target pests	Percentage of acreage treated	Treated acres	Fungicide use-lb ai
sulfur (C)	OK	3.13	F	2	White rust, blue mold, Anthracnose	20	656	4,107
sulfur (C)	TN	3.13	F	1.5	White rust, blue mold, Anthracnose, Cercospora leaf spot	10	200	939
					U.S. Totals (of states reporting) →			**5,046**
thiram (O)	NY	0.05	ST	1	Seedling diseases	50	850	43
thiram (O)	NC	0.03	ST	1	Seedling diseases	90	900	27
thiram	TN	0.03	ST	1	Seedling diseases	100	2,000	60
thiram	TX	0.03	ST	1	Seedling diseases	50	6,000	180
					U.S. Totals (of states reporting) →			**310**
					SPINACH SEED PRODUCTION			
benomyl (R)(O)	WA	0.001	ST	1	Fusarium wilt	100	3,500	4
captan (B)(R)	WA	0.03	ST	1	Seedling diseases	100	3,500	105
chlorothalonil (R)	WA	1.44	F	1	Blue mold, Alternaria leaf spot	20	700	1,008
copper (R)	WA	1.50	F	1	Blue mold, Alternaria leaf spot	20	700	1,050
metalaxyl (D)	WA	0.18	F	1	Blue mold	20	700	126
metalaxyl (C)	WA	0.25	F	1	Blue mold	20	700	175
metalaxyl (B)(O)	WA	0.006	ST	1	Seedling diseases, blue mold	100	3,500	21

[1] Used in combination with: (B) = benomyl, (C) = copper, (D) = chlorothalonil, (O) = captan, (R) = metalaxyl, (S) = sulfur, and (T) = thiram, each of which should be consulted for use rates, target pests and total usage of the combination chemical.

[2] Fungicide timing: F = foliar, PP = preplant, ST = seed treatment.

TABLE 22. Impact of the Loss of Individual Fungicides on the Production of Spinach
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide[1]	Timing[2]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[3]	% of acreage currently treated	Acreage currently treated	% Yield impact[4] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
captan	ST	AR	thiram (100)	100	1,000	0	0
captan	ST	AZ	thiram (100)	100	530	0	0
captan	ST	CA	thiram (100)	100	10,558	0	0
captan	ST	DE	thiram (100)	100	800	0	0
captan	ST	FL	thiram (100)	100	300	0	0
captan	ST	GA	thiram (100)	100	80	0	0
captan	ST	MD	thiram (100)	100	2,700	0	0
captan (T)	ST	NC	None (thiram already used)	90	900	0	0
captan	ST	NJ	thiram (100)	100	2,551	0	0
captan	ST	NY	thiram (100)	100	1,700	0	0
captan	ST	OH	thiram (100)	100	65	0	0
captan	ST	OK	thiram (100)	100	3,280	0	0
captan	ST	SC	thiram (100)	100	150	0	0
captan	ST	TX	thiram (50)	50	6,000	0	0
captan	ST	VA	thiram (100)	100	1,200	0	0
			U.S. Totals (of states reporting) →	**79.7**	**31,814**	**0**	**0**
copper	F	AR	fosetyl-Al (30)	30	300	- 5	- 88,500
copper	F	AZ	fosetyl-Al (5), resistant varieties (5)	10	53	- 5	- 30,290
copper	F	DE	fosetyl-Al (10)	50	400	- 10	- 312,000

TABLE 22. Impact of the Loss of Individual Fungicides on the Production of Spinach
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide[1]	Timing[2]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[3]	% of acreage currently treated	Acreage currently treated	% Yield impact[4] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper	F	FL	None	10	30	-5	- 7,500
copper	F	GA	fosetyl-Al (18)	85	68	- 25	- 199,750
copper	F	MD	fosetyl-Al (10)	40	1,080	- 10	- 874,800
copper	F	NJ	fosetyl-Al (10)	50	1,276	- 10	- 994,890
copper	F	NY	fosetyl-Al (90), resistant varieties (30), rotation (50)	95	1,615	15	2,337,713
copper	F	SC	None	50	75	- 20	- 150,000
copper	F	TX	Resistant varieties (83)	83	9,960	- 30	- 41,832,000
copper	F	VA	fosetyl-Al (20)	50	600	- 20	- 720,000
			U.S. Totals (of states reporting) →	**38.7**	**15,457**	**- 8.5**	**- 42,872,017**
copper + metalaxyl	F	AR	fosetyl-Al (50)	50	500	- 10	- 295,000
copper + metalaxyl	F	DE	fosetyl-Al (10)	10	80	- 5	- 31,200
copper + metalaxyl	F	FL	fosetyl-Al (10)	10	30	- 3	- 4,500
copper + metalaxyl	F	GA	fosetyl-Al (8)	75	60	- 42	- 296,100
copper + metalaxyl	F	MD	fosetyl-Al (10)	10	270	- 5	- 109,350
copper + metalaxyl	F	NJ	fosetyl-Al (10)	10	255	- 5	- 99,489
copper + metalaxyl	F	NY	fosetyl-Al (88)	88	1,496	- 5	- 721,820
copper + metalaxyl	F	OH	fosetyl-Al (10)	85	55	- 10	- 60,775
copper + metalaxyl	F	OK	Resistant varieties (5), premature harvest (10)	15	492	- 10	- 492,000
copper + metalaxyl	F	SC	fosetyl-Al (5)	20	30	- 10	- 30,000

TABLE 22. Impact of the Loss of Individual Fungicides on the Production of Spinach 1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide[1]	Timing[2]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[3]	% of acreage currently treated	Acreage currently treated	% Yield impact[4] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
copper + metalaxyl	F	TX	None	2	240	.- 30	- 1,008,000
copper + metalaxyl	F	VA	fosetyl-Al (20)	50	600	- 25	- 900,000
			U.S. Totals (of states reporting) →	**10.3**	**4,108**	**- 0.8**	**- 4,048,234**
copper + sulfur	F	OK	Resistant varieties (17.5), premature harvest (10)	20	656	- 5	- 328,000
copper + sulfur	F	TN	Resistant varieties (10)	10	200	- 1	- 16,000
			U.S. Totals (of states reporting) →	**2.1**	**856**	**- 0.07**	**- 344,000**
fosetyl-Al	F	AZ	Resistant varieties (10)	10	53	- 5	- 30,290
fosetyl-Al	F	CA	Resistant varieties (40)	45	4,751	- 35	- 30,098,219
fosetyl-Al	F	DE	None	10	80	- 25	- 156,000
fosetyl-Al	F	FL	None	2	6	- 5	- 1,500
fosetyl-Al	F	GA	metalaxyl + copper (2)	2	2	- 5	- 940
fosetyl-Al	F	MD	None	10	270	- 25	- 546,750
fosetyl-Al	F	NJ	None	10	255	- 25	- 497,445
fosetyl-Al	F	SC	metalaxyl + copper (5)	5	8	0	0
			U.S. Totals (of states reporting) →	**13.6**	**5,425**	**- 6.2**	**- 31,331,143**
metalaxyl	PP	AR	None	100	1,000	- 35	- 2,065,000
metalaxyl	PP	AZ	None	25	133	- 10	- 151,448
metalaxyl	PP	CA	None	70	7,391	- 25	- 33,442,465
metalaxyl	PP	DE	None	50	400	- 25	- 780,000

TABLE 22. Impact of the Loss of Individual Fungicides on the Production of Spinach
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide[1]	Timing[2]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[3]	% of acreage currently treated	Acreage currently treated	% Yield impact[4] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
metalaxyl	PP	FL	None	10	30	- 10	- 15,000
metalaxyl	PP	GA	None	100	80	- 20	- 188,000
metalaxyl	PP	MD	None	100	2,700	- 25	- 5,467,500
metalaxyl	PP	NJ	None	100	2,551	- 25	- 4,974,450
metalaxyl	PP	NY	None	99	1,683	- 10	- 1,624,095
metalaxyl	PP	OH	None	85	55	- 50	- 303,875
metalaxyl	PP	OK	None	50	1,640	- 4	- 656,000
metalaxyl	PP	SC	None	100	150	- 50	- 750,000
metalaxyl	PP	TX	None	95	11,400	- 30	- 47,880,000
metalaxyl	PP	VA	None	100	1,200	- 20	- 1,440,000
			U.S. Totals (of states reporting) →	**76.2**	**30,412**	**- 19.8**	**- 99,737,833**
thiram (O)	ST	NC	None (already using captan)	90	900	- 12.5	- 900,000
thiram	ST	NY	None (already using captan)	50	850	0	0
thiram	ST	TN	captan (100)	100	2,000	0	0
thiram	ST	TX	captan (50)	50	6,000	0	0
			U.S. Totals (of states reporting) →	**24.4**	**9,750**	**- 0.2**	**- 900,000**
SPINACH SEED PRODUCTION							
benomyl (O)(R)	ST	WA	None	100	3,500	- 5	- 315,000 lb seed
captan (B)(R)	ST	WA	thiram (100)	100	3,500	0	0 lb seed

TABLE 22. Impact of the Loss of Individual Fungicides on the Production of Spinach
1992 NAPIAP Leafy Green Fungicide Assessment - Sorted by Fungicide-State

"Lost" fungicide[1]	Timing[2]	State	Alternatives that would be used if the fungicide in column 1 were lost (% use)[3]	% of acreage currently treated	Acreage currently treated	% Yield impact[4] if fungicide is lost and alternatives are used	Yield impact (pounds leaf) if the fungicide is lost and alternatives are used
chlorothalonil + metalaxyl	F	WA	None	20	700	- 20	- 252,000 lb seed
copper + metalaxyl	F	WA	None	20	700	- 15	- 189,000 lb seed
metalaxyl (O)(B)	ST	WA	None	100	3,500	- 7	- 441,000 lb seed

1 Used in combination with: (B) = benomyl, (O) = captan, (R) = metalaxyl, (T) = thiram; should be consulted with use rates, target pests and total usage of the combination chemical.
2 Fungicide application timing: F = foliar, PP = preplant, ST = seed treatment
3 Alternatives are other fungicides or nonpesticide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide, unless there is nontreatment or overlap treatment on the formerly treated acreage.
4 Yield impacts are plus (+) or minus (-) and represent the percent yield change (up to maximum of 100%) on the acreage presently treated with the "lost" fungicide. U.S. totals are based on the 1992 planted acreage in each reporting state. Yield figures (for greens) for Washington state are not included because crop production there is only for seed production.

TABLE 23. Impact of the Loss of Fungicide Groups on the Production of Spinach
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Foliar fungicides	AR	None	80	800	- 90	- 4,248,000
Foliar fungicides	AZ	Resistant varieties (20)	20	106	- 10	- 121,158
Foliar fungicides	CA	None	45	4,751	- 40	- 34,397,964
Foliar fungicides	DE	None	70	560	- 80	- 3,494,400
Foliar fungicides	FL	None	22	66	- 7	- 23,100
Foliar fungicides	GA	None	100	80	- 90	- 846,000
Foliar fungicides	MD	None	60	1,620	- 50	- 6,561,000
Foliar fungicides	NJ	None	70	1,786	- 80	- 11,142,768
Foliar fungicides	NY	Rotation (70), resistant varieties (30)	100	1,700	- 20	- 3,281,000
Foliar fungicides	OH	None	85	55	- 70	- 425,425
Foliar fungicides	OK	Resistant varieties (17.5), early harvest (10), adjust cutting height (5)	35	1,148	- 15	- 1,722,000
Foliar fungicides	SC	None	75	113	- 50	- 562,500
Foliar fungicides	TN	None	10	200	- 1	- 16,000
Foliar fungicides	TX	None	85	10,200	- 30	- 42,840,000
Foliar fungicides	VA	None	100	1,200	- 40	- 2,880,000
		U.S. Totals (of states reorting) →	**61.1**	**24,385**	**- 22.3**	**- 112,561,315**
Preplant fungicides	AR	None	100	1,000	- 35	- 2,065,000
Preplant fungicides	AZ	None	25	133	- 10	- 151,448
Preplant fungicides	CA	None	70	7,391	- 25	- 33,442,465

TABLE 23. Impact of the Loss of Fungicide Groups on the Production of Spinach
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Preplant fungicides	DE	None	50	400	- 25	- 780,000
Preplant fungicides	FL	None	10	30	- 10	- 15,000
Preplant fungicides	GA	None	100	80	- 20	- 188,000
Preplant fungicides	MD	None	100	2,700	- 25	- 5,467,500
Preplant fungicides	NJ	None	100	2,551	- 25	- 4,974,450
Preplant fungicides	NY	None	99	1,683	- 10	- 1,624,095
Preplant fungicides	OH	None	85	55	- 50	- 303,875
Preplant fungicides	OK	None	50	1,640	- 4	- 656,000
Preplant fungicides	SC	None	100	150	- 50	- 750,000
Preplant fungicides	TX	None	95	11,400	- 30	- 47,880,000
Preplant fungicides	VA	None	100	1,200	- 20	- 1,440,000
		U.S. Totals (of states reporting) →	**76.2**	**30,412**	**- 19.8**	**- 99,737,833**
Seed-treatment fungicides	AR	None	100	1,000	- 20	- 1,180,000
Seed-treatment fungicides	AZ	None	100	530	- 7	- 424,053
Seed-treatment fungicides	CA	None	100	10,558	0	0
Seed-treatment fungicides	DE	None	100	800	- 15	- 936,000
Seed-treatment fungicides	FL	None	100	300	- 20	- 300,000
Seed-treatment fungicides	GA	None	100	80	- 10	- 94,000
Seed-treatment fungicides	MD	None	100	2,700	- 12.5	- 2,733,750
Seed-treatment fungicides	NJ	None	100	2,551	- 15	- 2,984,670

TABLE 23. Impact of the Loss of Fungicide Groups on the Production of Spinach
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Fungicide Group-State

"Lost" Fungicide Group	State	Alternatives that would be used if the fungicide group in column 1 were lost (% use)[1]	% of acreage currently treated	Acreage currently treated	% Yield impact[2] if fungicide group is lost and alternatives are used	Yield impact (lb leaf) if the fungicide group is lost and alternatives are used
Seed-treatment fungicides	NY	None	100	1,700	- 25	- 4,101,250
Seed-treatment fungicides	NC	None	90	900	- 12.5	- 900,000
Seed-treatment fungicides	OH	None	100	65	- 12.5	- 89,375
Seed-treatment fungicides	OK	None	100	3,280	- 15	- 4,920,000
Seed-treatment fungicides	SC	None	100	150	- 60	- 900,000
Seed-treatment fungicides	TN	None	100	2,000	- 5	- 800,000
Seed-treatment fungicides	TX	None	100	12,000	- 2	- 3,360,000
Seed-treatment fungicides	VA	None	100	1,200	- 20	- 1,440,000
		U.S. Totals (of states reporting) →	**99.8**	**39,814**	**- 5.0**	**- 25,163,098**
SPINACH SEED PRODUCTION						
Foliar fungicides	WA	None	40	1,400	- 40	- 1,008,000 lb seed
Seed-treatment fungicides	WA	None	100	3,500	- 12	- 756,000 lb seed

[1] Alternatives are other fungicides, fungicide groups, or nonfungicide controls. Percent use is the best estimate of the portion of the acreage currently treated by the "lost" fungicide group that would be treated with each alternative. The alternatives collective percent use should equal that for the "lost" fungicide group, unless there is nontreatment or overlap treatment on the formerly treated acreage.

[2] Yield impacts are plus (+) and minus (-) and represent the percent yield change (up to a maximum of 100%) on the acreage presently treated with the "lost" fungicide group. U.S. totals are based on 1992 planted acreage in each reporting state.

TABLE 24. Nonpesticide Control Practices for Pests on Spinach
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Acreage Where Practiced	Acreage where Practiced
Furrow irrigation	TX	White rust, blue mold	60	7,200
		U.S. Totals (of states reporting) →	**18**	**7,200**
Resistant varieties	NY	Blue mold	5	85
Resistant varieties	TX	White rust, blue mold	85	10,200
		U.S. Totals (of states reportng) →	**25.8**	**10,285**
Rotation	AR	Seedling diseases	100	1,000
Rotation	AZ	Seedling diseases	100	530
Rotation	CA	Seedling diseases	100	10,558
Rotation	DE	Seedling diseases, white rust	100	800
Rotation	FL	Seedling diseases	95	285
Rotation	GA	Seedling diseases	100	80
Rotation	MD	Seedling diseases, white rust	100	2,700
Rotation	NJ	Seedling diseases, white rust	100	2,551
Rotation	NY	Seedling diseases, white rust	30	510
Rotation	NC	Seedling diseases	100	1,000
Rotation	OH	Seedling diseases	100	65
Rotation	OK	Seedling diseases	75	2,460
Rotation	SC	Seedling diseases	100	150
Rotation	TN	Seedling diseases	15	300
Rotation	TX	Seedling diseases	100	12,000
Rotation	VA	Seedling diseases, white rust	100	1,200
		U.S. Totals (of states reporting) →	**90.7**	**36,189**

TABLE 24. Non-pesticide Control Practices for Pests on Spinach
1992 NAPIAP Leafy Greens Fungicide Assessment - Sorted by Practice-State

Control Practice[1]	State	Target pest(s)	Percentage of State Collards Acreage Where Practiced	Acreage where Practiced
SPINACH SEED PRODUCTION				
Rotation	WA	Seedling diseases, white mold, Fusarium wilt	100	3,500

[1] Rotation = in the preceding year, the percentage of the current crop acreage (1992) that had an alternate crop on it.

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PI27-94